CROSSBAR DIAL SYSTEM

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(ISSUED FOR TRAINING PURPOSES ONLY)

FOREWORD

These notes present the Crossbar Dial System in three separate sections, each of which is a description of the complete system.

The first section, covered in Chapters 1 to 4 inclusive, gives a brief over-all description of crossbar designed to lay a fundamental groundwork for a study of the system. This section should also prove of value to those desiring only a general understanding of the method of handling calls in the crossbar system.

The second section, covered in Chapters 5 to 12, is also complete in itself but goes into considerably greater detail concerning the functions of the various crossbar system frames with respect to each other. These functions are discussed from the traffic, equipment and circuit points of view. Besides laying a further groundwork for the study of the crossbar system circuits, this section should be of assistance to those who require a working knowledge of the crossbar system without the actual details of the various circuits.

The third section, which includes Chapters 13 to 30, discusses the circuit features of the system in considerable detail, using abbreviated circuit sketches as a basis for the description.

Valuable assistance in the preparation of these notes has been received from various members of the Laboratories' technical staff, in the form of sketches, advice and comments on the written material. Appreciation is also expressed to the New York Telephone Company and to the Western Electric Company for numerous sketches which have been included herein.

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CROSSBAR SYSTEM

TABLE OF CONTENTS

CHAPTER	SUBJECT
SECTION I - FUNDAMENTAL APPROACH TO CROSSBAR SYSTEM	
1	Apparatus and Fundamentals
2	Crossbar System - Frames
3	Crossbar System - Originating Calls
4	Crossbar System - Terminating Calls
SECTION II - EQUIPMENT ARRANGEMENT WITH TRAFFIC AND CIRCUIT FUNCTIONS OF CROSSBAR SYSTEM FRAMES	
5	Line Link Frame - District Junctor Distribution
6	Subscriber Sender Link, District Junctor, and District Link Frames - Zone Registration
7	Office Link Frame - Office Junctor Distribution
8	Originating Sender and Decoder Marker Connector Frames
9	Originating Marker Frame
10	Terminating Sender Link, Incoming Trunk, and Incoming Link Frames - Line Junctor Distribution
11	Terminating Senders, Number Group Connector, Block Relay, and Terminating Marker Frames - Line Test
12	Line Choice Connector, Line Junctor Connector, and Terminating Marker Frames - Channel Selection - Trouble Indicators
SECTION III - CROSSBAR SYSTEM CIRCUITS	
13	Crossbar Circuit Features
14	Connecting Subscriber Sender to Calling Line
15	Registration of Called Number
16	Subscriber Sender - Information to Originating Marker
17	Originating Marker - Translation of Office Code
18	Outgoing Trunk Test and Selection
19	Channel Test and Selection
20	Call Established to Outgoing Trunk
21	Selection of Terminating Sender and Registration of Called Number
22	Terminating Sender - Incoming Advance - Seizure of Terminating Marker
23	Selection and Test of Called Line
24	Selection of Channel and Operation of Switch Magnets
25	Line Continuity Test, Ringing the Called Subscriber, and Disconnect of Terminating Marker and Sender
26	PCI Calls
27	Special Calls
28	Operation of Coin Circuits
29	Key Pulsing "A" Switchboard
30	Call Distributing "B" Switchboard

SECTION I - FUNDAMENTAL APPROACH TO CROSSBAR SYSTEM

CHAPTER I - APPARATUS AND FUNDAMENTALS

There are two dial systems in general use in the Bell System today, the step-by-step and the panel systems. A third system known as the crossbar dial system has recently been developed in these Laboratories. Although the two earlier systems are quite satisfactory and represent definite advances in the telephone art it is expected that the crossbar system will offer certain important advantages such as lower maintenance cost, shorter call completing times, and better transmission characteristics due to the use of precious metal contacts.

The crossbar system has been developed in its present form for use in large metropolitan areas. It will operate with existing panel offices and with existing call indicator, tandem, and toll installations. The same classes of service available to the public in panel offices will also be available with the use of the crossbar system. Complete interconnection between panel and crossbar and between crossbar and manual has been provided in all respects.

The switching apparatus and the method of setting up calls differ in principle from those of either the step-by-step or panel systems. These two systems employ mechanical hunting for the various switching functions. This motion is furnished by magnetically operated ratchets as in the step-by-step system or by power driven rods as in the panel system. These devices cause brushes to wipe over contacts in either rotary or linear motion to set up the desired electrical connections. Base metal is generally used for the contacting material in the switching mechanisms of these systems.

The crossbar system is different from panel and step-by-step in that it is essentially a relay system. Mechanical motion has been largely reduced so as to be comparable to that required to close or open contacts in relays used in telephone systems. Precious metal contacts are employed for all circuit closures.

The system, in general, employs new apparatus as follows: the crossbar switch, multicontact relay and the "U" and "Y" type relays. The only power driven apparatus, aside from the power supply machines, are reciprocating bar interrupters similar to those used in the panel system, and certain new self-contained timing mechanisms used for the timing of telephone calls.

DESCRIPTION OF CROSSBAR SWITCH

Figs. 1 and 2 illustrate what is known as a "100 point crossbar switch". In principle it is a relay with 100 sets of contact springs, each set of springs capable of being operated independently of any other set. These sets of contacts are arranged in a rectangular field of ten horizontal rows and ten vertical rows and are operated by horizontal and vertical bars. The horizontal bars are controlled by "selecting" magnets and the vertical bars by "holding" magnets. Briefly, any set of contacts may be closed by the operation of the selecting magnet which determines the horizontal row, followed by the operation of a holding magnet which determines the particular set in that row. The set of contacts then remains operated under the control of the holding magnet, the selecting magnet being permitted to release.

CONTACTS

Each set of contacts is referred to as a "crosspoint" and consists of 3, 4, 5 or 6 pairs of normally opened or "make" springs equipped with twin precious metal contacts (see Fig. 4). The object of the twin contacts is to reduce greatly the chances of contact trouble over what they might be if only one contact were provided for each pair of springs. One spring of each pair is stationary and consists of one of ten projections on a vertical metal "multiple strip" extending from the top set to the bottom set of contacts in each vertical row. This means that a given stationary or "fixed" spring in a set of contacts at a crosspoint is multipled with the corresponding stationary spring at each of the crosspoints in the same vertical row. A "Y" shaped wiring lug is provided at the bottom of each multiple strip. The conductors of a line or trunk, if wired to the "Y" terminals at the bottom of a vertical row, will, therefore, be multipled to the ten sets of fixed contacts in that row. The movable or "operating" spring of each pair extends to the rear of the switch where it may be individually wired as required. These latter springs are flexible and when operated their contacts are forced against the contacts of the corresponding fixed springs by a relay-like movement.

HORIZONTAL BARS

Each switch includes five horizontal or "selecting" bars as shown on Fig. 1, one bar for each pair of adjacent horizontal rows. Each bar is attached at one end to a butterfly shaped armature, this armature being controlled by either of two "selecting" magnets. The operation of one of these two magnets will rotate the bar through a small arc in one direction while the operation of the other magnet will rotate it in the opposite direction.

SELECTING FINGERS

On each selecting bar are mounted ten flexible wires with spring hinges (see Fig.4). These wires are called "selecting fingers" and are located very close to the vertical rows of contacts. When the selecting finger is in its normal position it rests mid-way between two sets of contacts on the corresponding vertical as shown on Fig.5. With the lower selecting magnet operated each selecting finger on the bar will be rotated to a position opposite the upper set of the contacts it controls. With the upper selecting magnet operated, however, each finger will be rotated in the opposite direction to a position adjacent to its lower set of contacts. No set of contacts can be closed so long as the corresponding selecting finger is in its normal position. The next step is to show how the operation of a "holding magnet" will cause the closing of a set of contacts in the associated vertical row if a selecting finger is in an operated position near that set of contacts.

HOLDING MAGNET AND VERTICAL BAR

Associated with each vertical row of crosspoints is a "holding magnet". The armature of this holding magnet controls a vertical or "holding" bar causing it to rotate through a small arc when the magnet is operated. This holding bar is illustrated on Fig. 1 and a small section of it is shown enlarged on Fig. 4. The set of contact springs at each crosspoint is provided with an "actuating spring" illustrated on Fig. 4 which transmits the pressure from the holding bar to the particular set of contacts. The holding bar when operated will not exert pressure on any actuating spring in the vertical row unless there is an operated selecting finger. If there is an operated selecting finger the pressure from the vertical bar will be transmitted to the actuating spring through the selecting finger and thus to the contacts themselves. The upward and downward travel of the selecting fingers is limited by tangs located on the actuating springs for the corresponding set of contacts. The space between the holding bar and the actuating spring, to which the selecting finger is moved preparatory to operating the corresponding set of contacts is referred to as a "trap".

After a set of contacts has been closed (the holding magnet remaining operated), no other sets of contacts in the same vertical row may be operated until after the holding magnet has been released. However, a set of contacts may be operated in each of the other vertical rows thus permitting a maximum of ten connections to be made through a 100 point crossbar switch.

VERTICAL UNIT

The ten sets of springs of a vertical row together with their associated holding magnet and vertical bar are assembled in a self-contained unit called a "vertical unit" or simply a "vertical". Ten of these units are required to make up a 100 point crossbar switch. Such a switch is 20-1/2" long and 9-1/4" high. Also, twenty vertical units are assembled to make a crossbar switch with 200 sets of contacts known as a "200 point crossbar switch" as illustrated on Fig. 3. This switch is 30-1/2" long and 9-1/4" high and at the present time is arranged to have not more than four pairs of make contacts per set. In this case each selecting bar is equipped with twenty selecting fingers.

Crossbar switches are referred to commonly in terms of the number of sets of contacts and the number of contacts in each set; thus, 100 point, 6 wire; 200 point, 4 wire; etc.

HORIZONTAL STRAPPING

As previously stated, the movable spring of each pair of contacts is extended to the rear of the switch where it may be individually wired as required. These springs are so designed, however, that any spring in a given vertical may be readily wired to the corresponding spring in other verticals by means of horizontal bare wire strapping. This means that, if this strapping is employed, the conductors of a line or trunk wired to the movable springs of a set of contacts on one vertical of the switch, will be multipled horizontally across all or a part of the verticals of the entire switch.

MULTICONTACT RELAY

The multicontact relay used in the crossbar system, as illustrated on Figs. 6A and 6B, resembles in design the vertical unit of the crossbar switch. This relay is really made up of an assembly of two relays on a common mounting, since each half of the relay has its own and separate magnet, armature and group of spring assemblies. Each structure may, therefore, be used as two independent relays or when desired may be used as one relay by multipling the two windings of the coils. These relays are not furnished with internal vertical strapping, each pair of contacts being individual. All contacts are make contacts.

The multicontact relay finds its chief application where a large number of leads must be connected from one circuit to another. It is available in two designs with respect to the soldering terminals at the rear. The relay shown on Fig. 6B is arranged for bare wire strapping for the multipling of alternate springs horizontally to the corresponding springs of two or more relays when mounted adjacent to each other. In the second type of relay illustrated on Fig. 7A, the strapping lugs are omitted and all springs are arranged for individual wiring only.

Fig. 7B illustrates a terminal strip which is provided for terminating the multiple strapping for a number of multicontact relays and for making connections to the common multiple.

MULTICONTACT SWITCH

A multicontact switch has been made available for use wherever it is desired to switch a number of leads manually, as for instance to transfer from one control circuit to another. This switch is shown on Fig 8 and is essentially a multicontact relay with the magnets omitted and replaced by a lever or key for actuating a plate which takes the place of the armature in the multicontact relay.

"U" TYPE RELAY

A new and improved general purpose relay is used in this system. This relay is shown on Fig. 9 and, although somewhat similar to the familiar "E" and "R" type relays, differs from the latter principally in that it has a heavier and more efficient magnetic structure which permits the use of a greater number of contact springs. The relay is equipped with twin contacts as are the crossbar switch and multicontact relay.

A variation of this relay, known as the "Y" type, is similar in appearance to the "U" type but is designed to be slow acting.

CROSSBAR SYSTEM FUNDAMENTALS

The fundamental method of using the crossbar switch in setting up connections is illustrated on Fig. 10A. This figure shows ten lines connected to the ten verticals of a 100 point crossbar switch and ten trunks strapped horizontally across the switch. With such a combination, any one of the ten lines may be connected to any one of the ten trunks. This principle, with variations, is employed on all the major crossbar system frames.

With the arrangement shown on Fig. 10A, any line would always be able to find an idle trunk, since the number of lines coming into the switch is exactly equal to the number of trunks going out and no busy condition would ever be encountered. This is not an efficient condition, however, since the calling rate on the lines involved would have to be heavy in order to use the ten trunks to capacity.

Fig. 10B shows a means of using the same ten trunks in a more efficient manner. A second 100 point crossbar switch has been added, this crossbar switch having ten different lines connected to its verticals. The horizontal multiple across the second switch has, however, been connected to the horizontal multiple of the original switch of Fig. 10A so that now twenty lines have access to the ten trunks instead of only ten lines. By adding other switches in this manner, any number of lines may be given access to ten trunks. It is also possible to use 200 point crossbar switches in the same manner to give two or more groups of twenty lines access to ten trunks.

Obviously, the usefullness of the crossbar system would be very small if it were limited to only ten trunks, for although any number of lines could be added to the system by hooking on other switches the point would soon be reached where the ten trunks would be overloaded. It would be possible, of course, to double the capacity of the system by duplicating the arrangement of Fig. 10B thus providing twenty trunks in all. Such an arrangement would not be entirely satisfactory, since each group of lines would still have access to only ten trunks. In order to obtain greatest efficiency, it is necessary to provide all of the lines with access to all of the trunks.

Such access is provided through the use of the "primary - secondary" switch principle, which is fundamental in the crossbar system and illustrated on Fig. 11. The "primary" switches are arranged in a manner similar to that shown on Fig. 10A, the trunks multipled horizontally on these switches being connected to the horizontal terminals of a group of switches known as "secondary" switches. The groups of trunks to which it is desired to connect the various lines are now wired to the verticals of the secondary switches. The connections between the horizontal terminals of the primary switches and the horizontal terminals of the secondary switches are referred to as "links". Any one of twenty lines can now have access to any one of twenty trunks via these links. It should be noted, however, that this access is limited, because if all five links between a primary and secondary switch were busy a given line on the primary switch would not be able to reach an idle trunk on that particular secondary switch.

The arrangement shown on Fig. 11 is introduced merely to illustrate the primary and secondary switch principle and is not used, in the form shown, in the crossbar system. Fig. 12 illustrates the principle of primary and secondary switches used in various forms on nearly all the major crossbar frames. Fig. 11 shows five links from each primary to each secondary switch. Fig. 12, on the other hand, shows ten primary switches and ten secondary switches, each primary switch having one link to each secondary switch. The result of this combination is that any line on any primary switch has limited access to any one of 100 outgoing trunks, with the advantage of obtaining the greatly increased traffic efficiency of the 100 trunk group over a number of ten or twenty trunk groups.

The arrangement shown on Fig. 12 is that employed on the line link frame in order to give a group of 100 lines access to 100 trunks. The links between primary and secondary switches are referred to as "line links" in this case. The number of lines having access to the 100 outgoing trunks is increased in size by adding other primary switches with their horizontal terminals in multiple with the primary switches shown on Fig. 12. Each group of primary switches having access to the same ten line links is referred to as "a horizontal group" and each horizontal group should contain the same number of lines.

The method of applying the primary-secondary principle to the various crossbar system frames will be discussed in the next chapter.

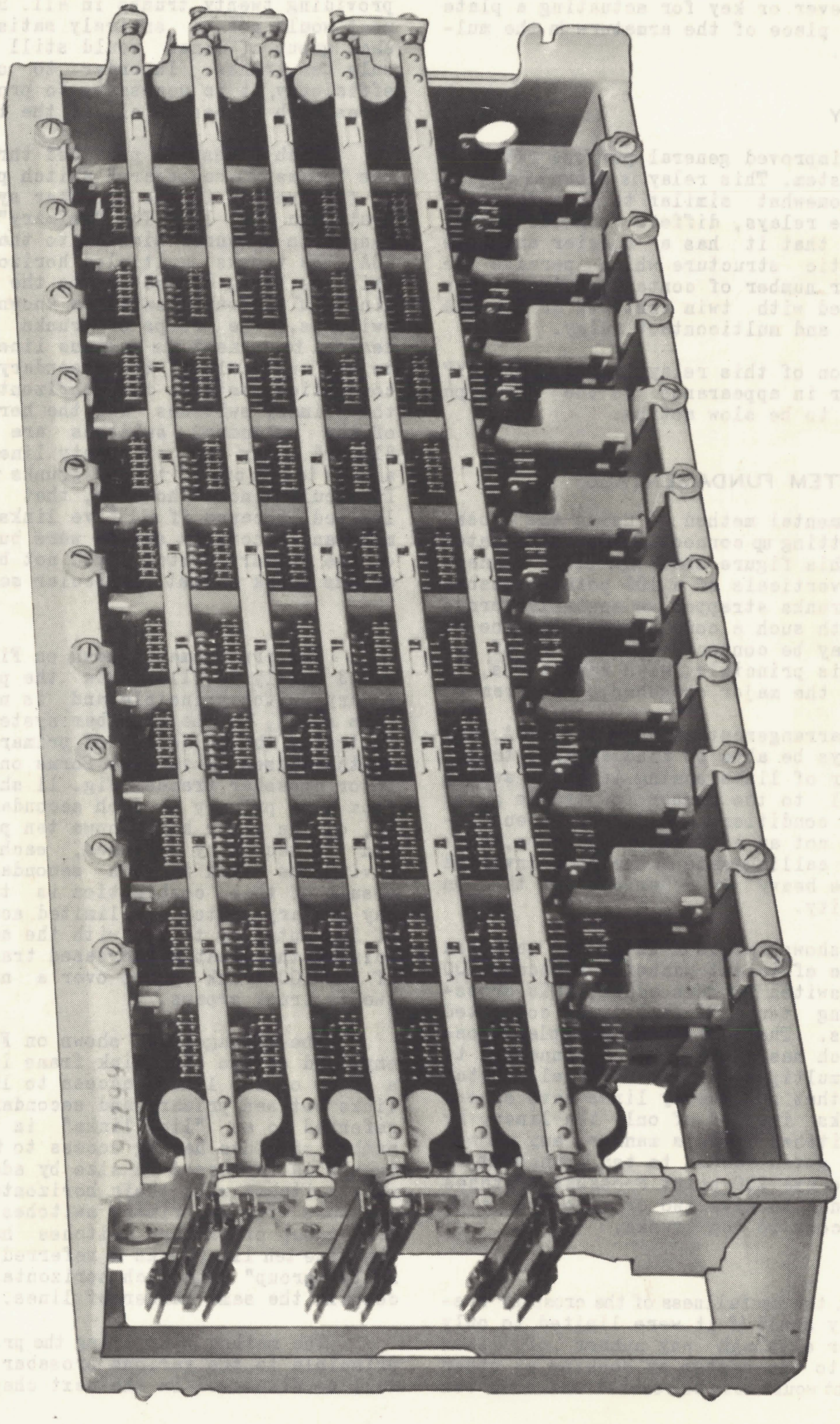


Fig. 1 Crossbar Switch Front View - Ten, 6 Wire Verticals

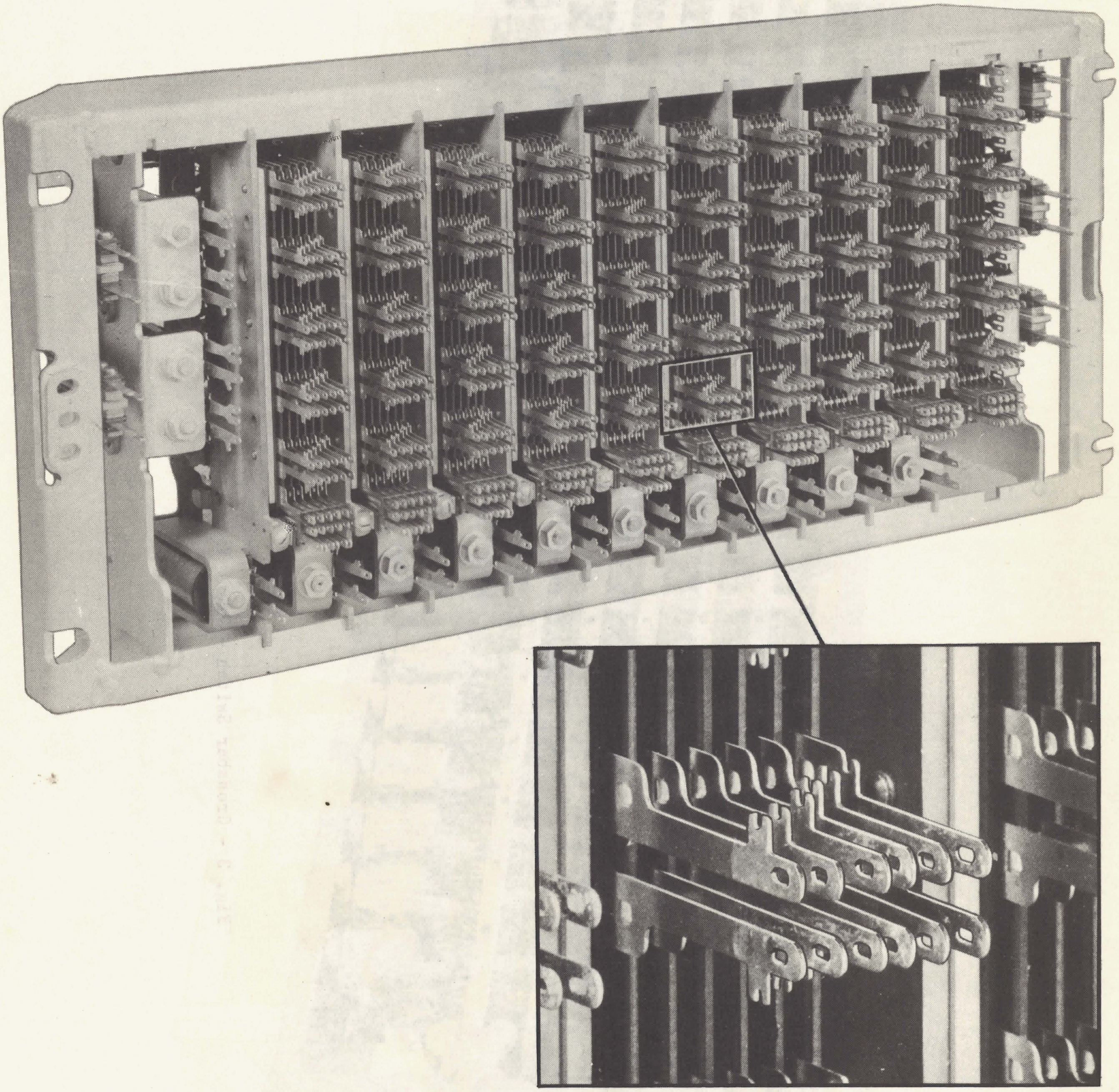


Fig. 2 - Crossbar Switch - Rear View - Ten, 6 Wire Verticals

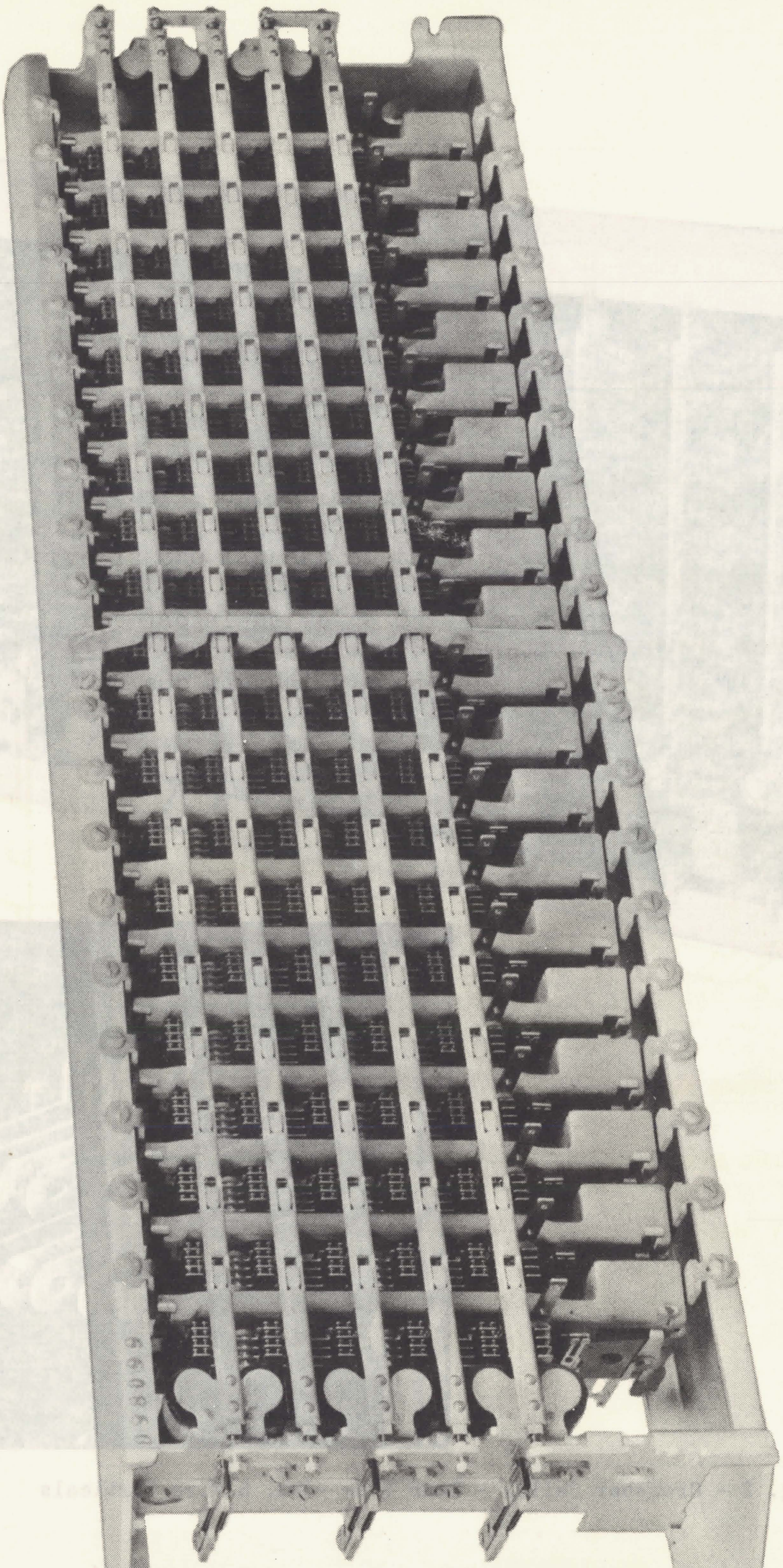


Fig. 3 - Crossbar Switch - Front View - Twenty, 4 Wire Verticals

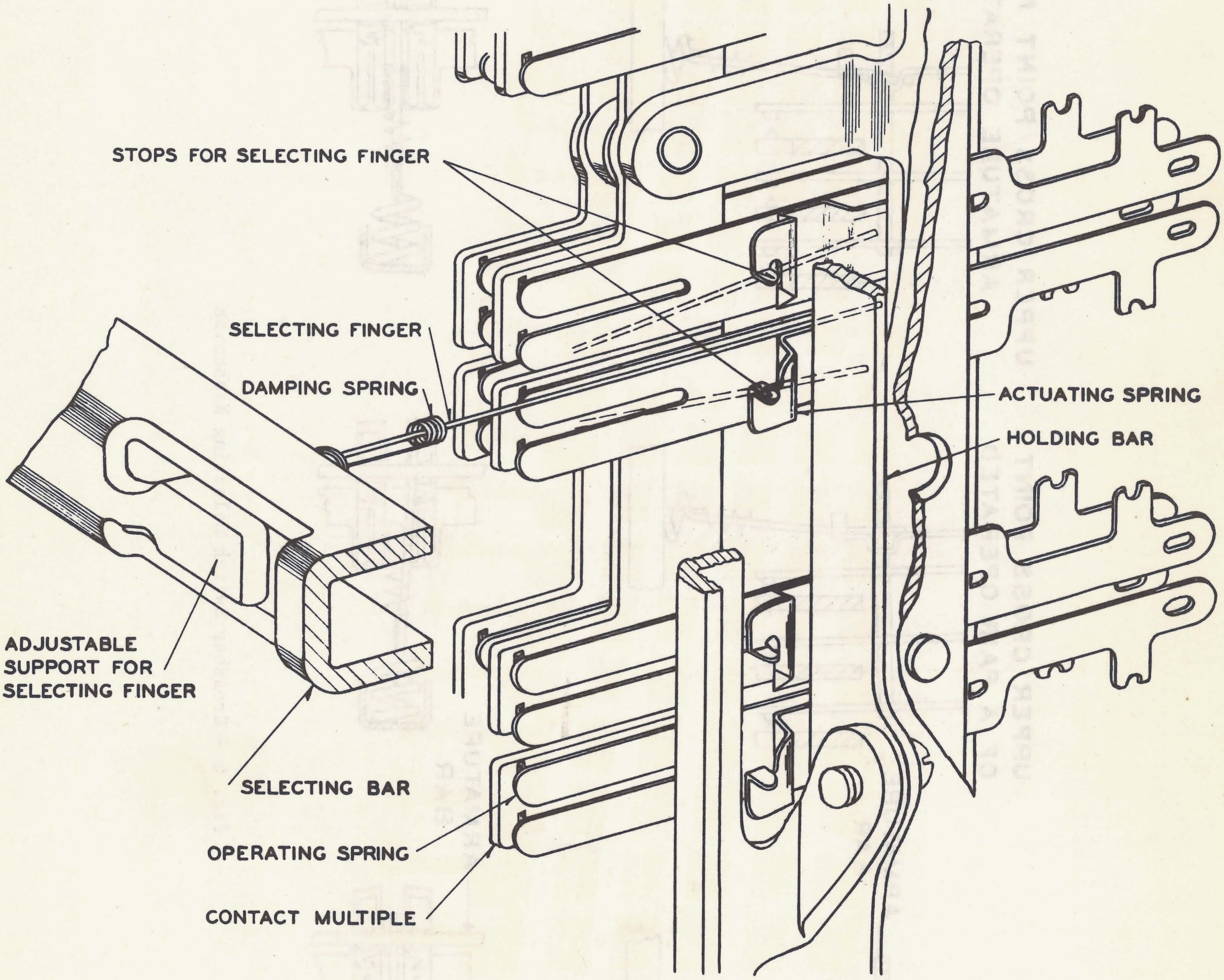


Fig. 4 - Crossbar Switch - Operating Principle

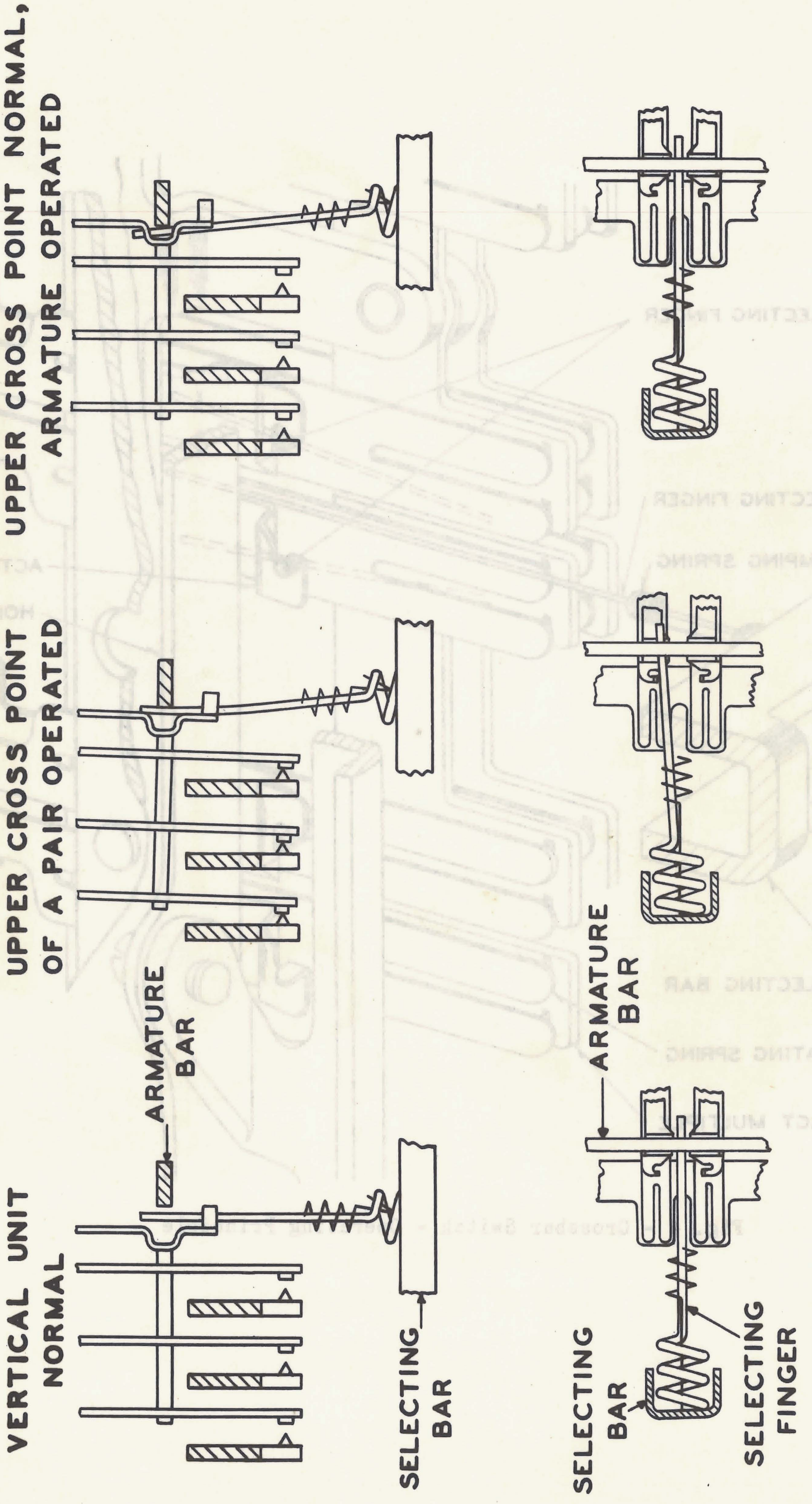


Fig. 5 - Crossbar Switch Selecting Mechanism

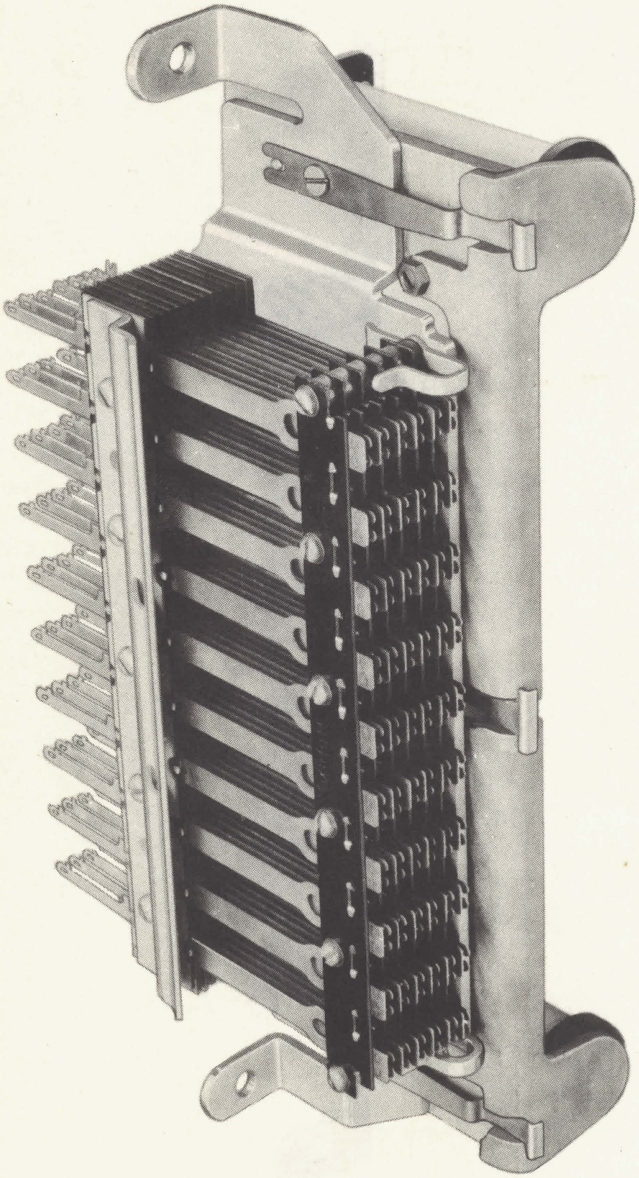


Fig. 6A

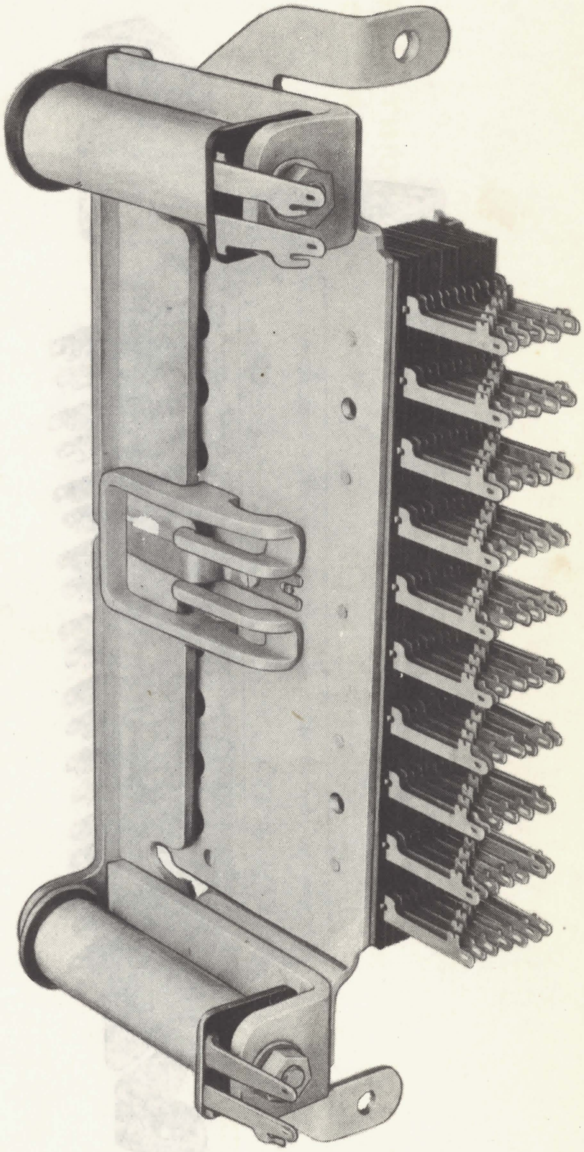


Fig. 6B

Multicontact Relay

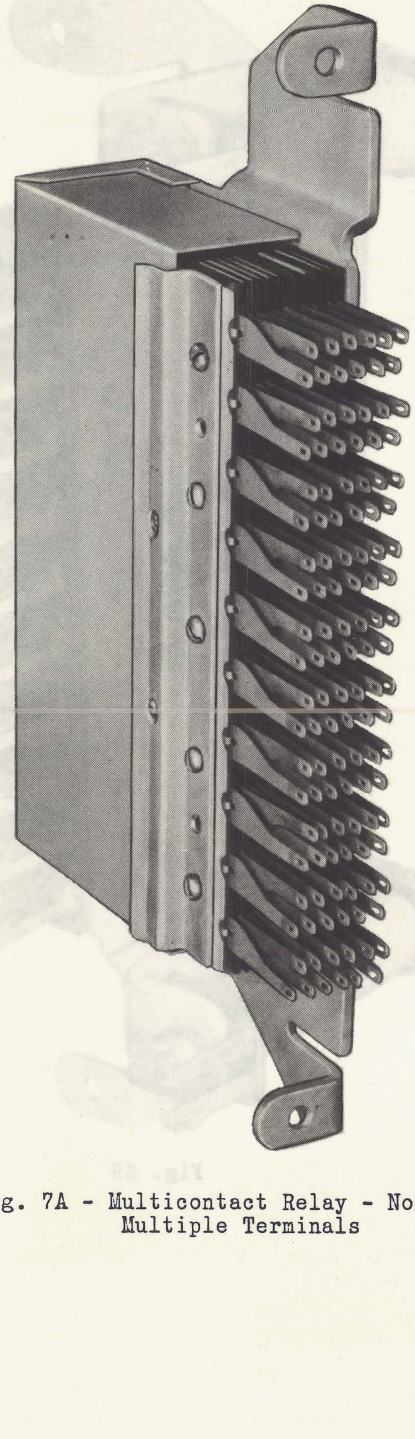


Fig. 7A - Multicontact Relay - Non-Multiple Terminals

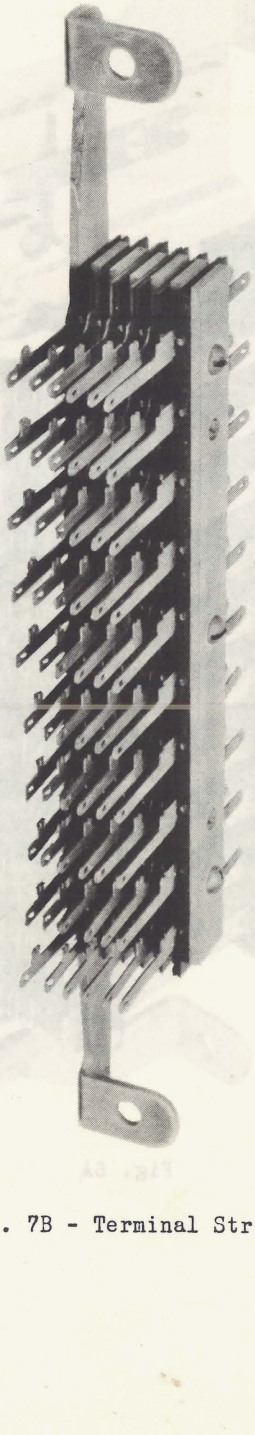


Fig. 7B - Terminal Strip

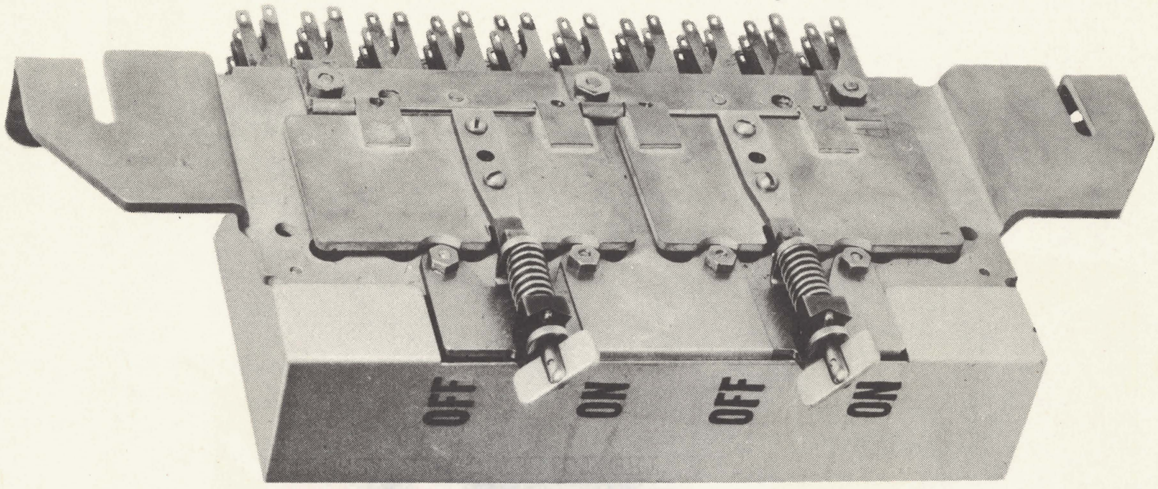


Fig. 8B

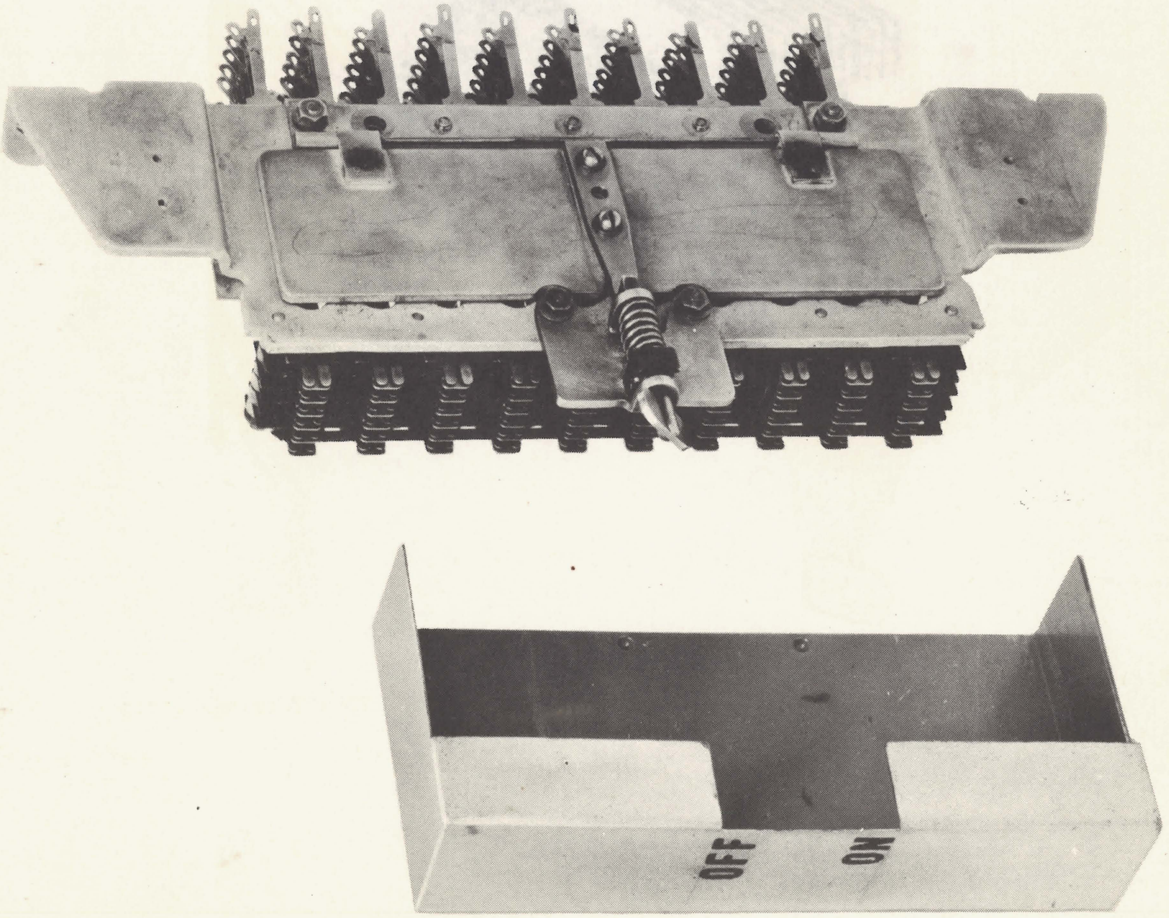


Fig. 8A

Multicontact Switch

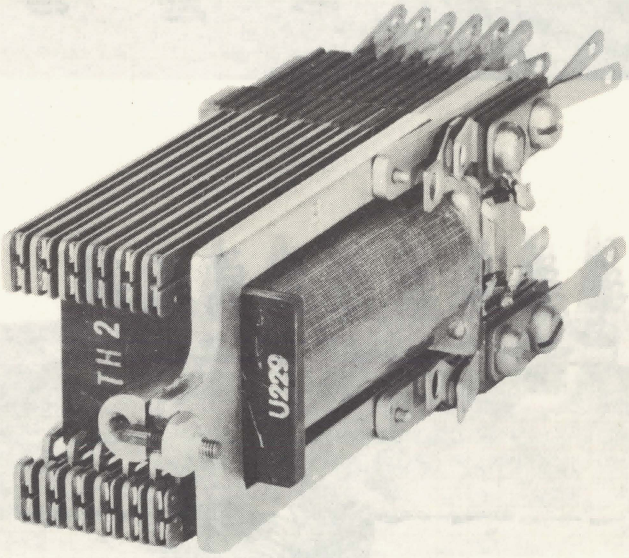


Fig. 9 - "U" Type Relay

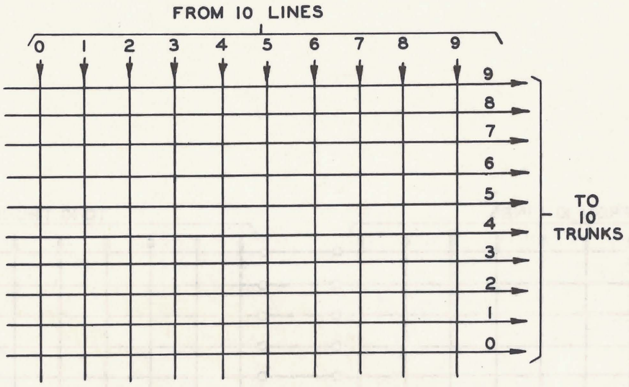


FIG. 10-A
100 POINT CROSSBAR SWITCH
USED TO CONNECT ANY ONE OF TEN LINES TO
ANY ONE OF TEN TRUNKS

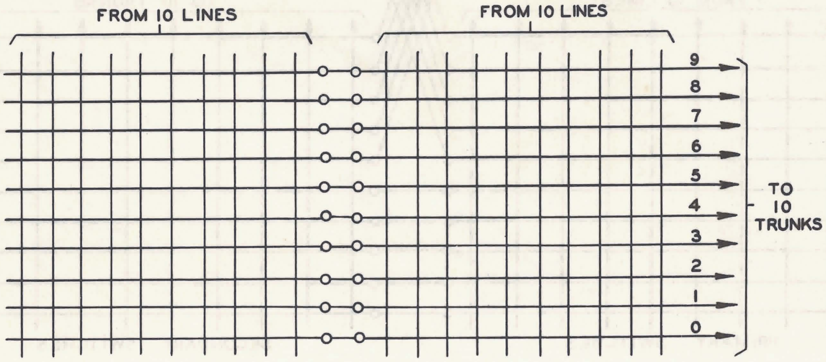


FIG. 10-B
TWO 100 POINT CROSSBAR SWITCHES
USED TO CONNECT ANY ONE OF TWENTY LINES
TO ANY ONE OF TEN TRUNKS

Fig. 10 - 100 Point Crossbar Switches Connecting
to Ten or Twenty Trunks

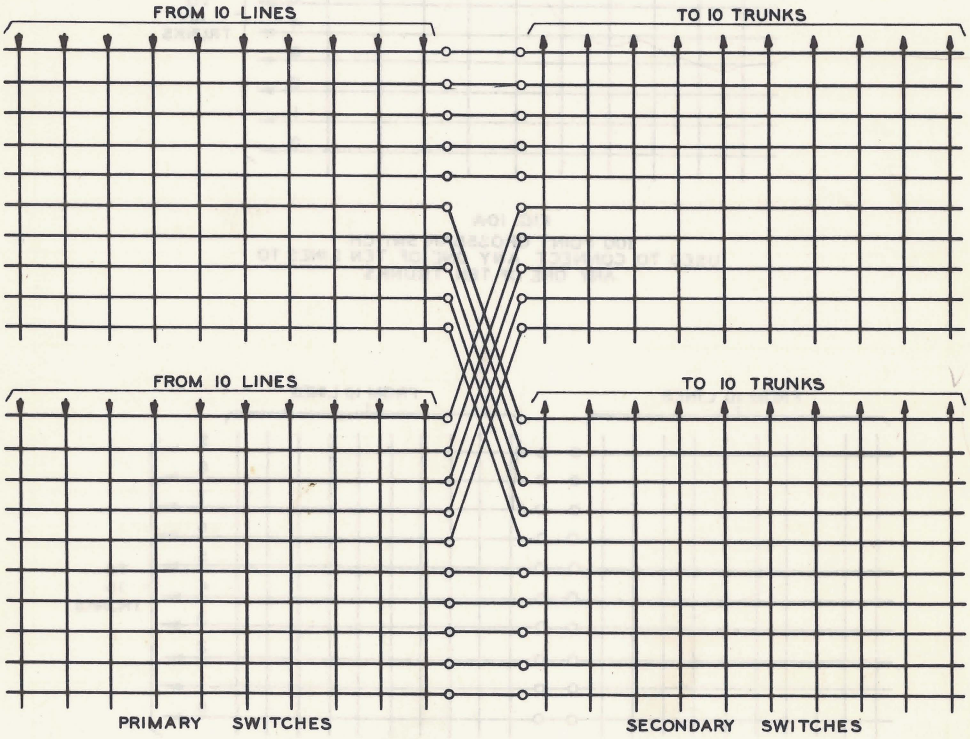


Fig. 11 - Primary-Secondary Switch Principle

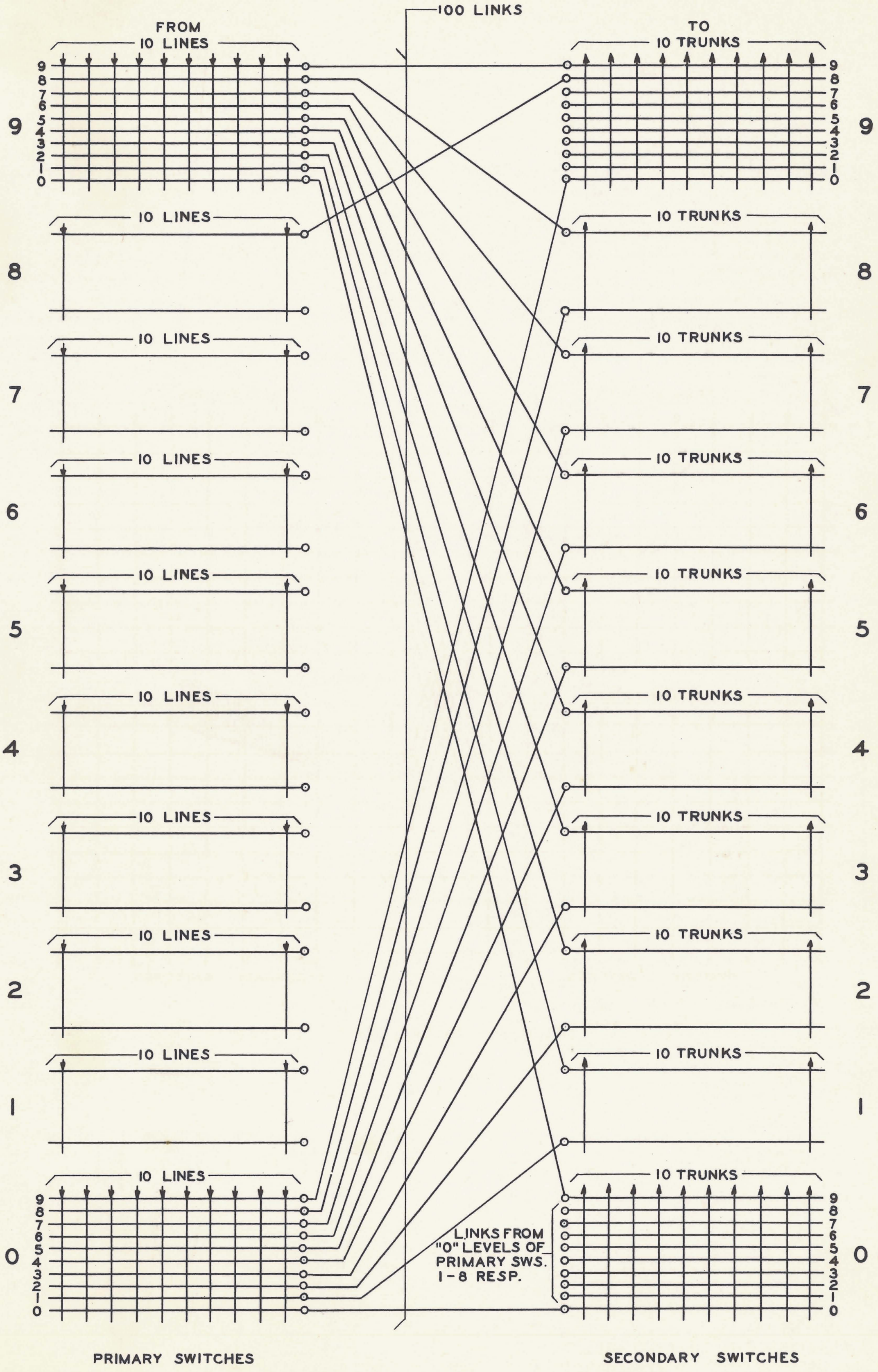


Fig. 12 - Primary-Secondary Switch Schematic

CHAPTER 2 - CROSSBAR SYSTEM - FRAMES

A discussion of the panel system is usually based on the numerous parallels which can be drawn between the functions of the various panel frames and the corresponding operations which take place in the manual system. It is much more difficult to draw parallels of this type between the crossbar system and manual. It is possible, however, to compare some of the major crossbar frames with panel frames which have much the same functions even though the general method of handling calls differs considerably from that used in the panel system. For this reason a brief review of the functions of the various panel frames will be of considerable benefit at this stage of the discussion.

PANEL SYSTEM FRAMES

The Line Finder Frame of the panel system has as its function the finding of the calling line and connecting it to a district selector. Each line finder is permanently wired to a district selector and the combination is referred to as a line finder district.

The Office Frame finds an idle trunk to the office whose code has been dialed by the calling subscriber. The office selector under the direction of the subscriber sender selects a set of terminals which represents an idle trunk.

The District Frame selects an idle trunk to the office frame. This trunk terminates in a selector on the office frame. This assumes that all outgoing trunks are located on the banks of office frames as they might be in metropolitan areas having a large number of trunk groups.

The Subscriber Sender receives the pulses dialed by the subscriber and controls all the selectors involved in building up the call to the called line.

The Link Frame is responsible for attaching an idle subscriber sender to a line finder district before the subscriber begins to dial.

The Decoder receives the office code from the sender and in turn gives the sender information required for controlling the various selections.

The Final Frame selects a particular called line under the influence of the sender. Each final selector has access to 500 subscriber lines.

The Incoming Frame under the influence of the sender selects a trunk to the particular final frame upon which the called line appears. This trunk terminates in a final selector.

CROSSBAR SYSTEM PARALLELS

There are certain parallels to the above panel system frames in the crossbar system. Keeping these parallels in mind will assist in the understanding of the crossbar system. Crossbar frames which perform similar functions to the various panel frames may be enumerated as follows:

Panel	Crossbar
Line Finder	Line Link
District	District Link
Subscriber Link	Subscriber Sender Link
Office	Office Link
Decoder	Originating Marker
Incoming	Incoming Link
Final	Line Link*

*As will be explained later the line link frame combines the functions of the panel line finder and final.

CROSSBAR SYSTEM NOMENCLATURE

There are several descriptive terms employed in the crossbar system which should be defined before proceeding to a further discussion of the crossbar system frames. Familiarity with these terms and their definitions is necessary for a clear understanding of the crossbar system call.

Each major crossbar system frame employs a primary-secondary arrangement of switches similar to that explained in the preceding chapter. On each frame the connection between the primary and the secondary switch is referred to as a "link" and the link is further described by the name of the frame on which it appears. Thus, line link, district link, office link, incoming link, etc.

The primary-secondary combination previously discussed showed trunks outgoing from the secondary switches. Where these trunks go to a succeeding crossbar frame they are referred to as "junctors". Each type of junctor takes its name from the frame to which it is going. Thus, junctors from line link secondary switches to district link primary switches are referred to as district junctors. Junctors from district link secondary switches to office link primaries are called office junctors. Junctors from incoming link secondaries to line link secondaries are called line junctors. The exception to this general rule is found in the case of incoming trunks which are outgoing from office link secondaries and incoming to incoming link primaries.

A particular set of contacts on a crossbar switch is referred to as a "crosspoint", this being the particular set of contacts closed by the operation of a selecting magnet and a holding magnet.

The horizontal multiple from the flexible spring contacts of one vertical on a crossbar switch to corresponding terminals on the remaining verticals of the switch is often called a "horizontal". Thus, a crossbar switch with its individual springs multipled horizontally is referred to as having ten horizontals. When the horizontal multiple is continuous across only a part of the switch, the switch is referred to as having "split horizontals".

CROSSBAR SYSTEM FRAMES

As a preliminary to the study of how crossbar calls are handled some knowledge of the major crossbar system frames is necessary. Fig. 1 illustrates a typical crossbar switch frame. In studying the following description of these frames it will be found helpful to keep the functions of the parallel panel frames in mind. Discussion of the manner in which the crossbar frames themselves function in handling calls will be reserved until after the frames have been described.

LINE LINK FRAME

The crossbar system line link frame performs, in general, the functions of the line finder and of the final frames of the panel system.

The trunking arrangement of the line link frame is illustrated schematically on Figs. 2 and 6A. It employs the primary-secondary arrangement of crossbar switches previously described. The line link frame is used both in originating and completing calls. An originating call is set up from the particular vertical on a primary switch on which the calling line appears, through a line link to a secondary switch and thus to an idle district junctor which appears on a vertical of a secondary switch. Since the 100 line links from primary switches are distributed over all secondary switches and there are a total of 100 district junctors to which a particular line link frame has access, any calling line may be connected to any idle district junctor in the 100. To set up such a combination the primary and secondary selecting magnets corresponding to a particular line link must be operated followed by the operation of the primary holding magnet corresponding to the calling line and the secondary holding magnet corresponding to an idle district junctor.

In general, 200 point switches are employed as secondary switches on the line link frame. Ten of the verticals on each secondary switch represent district junctors which are used on originating calls. The remaining ten verticals of each secondary switch represent line junctors from the incoming frame, 100 line junctors having access to each line link frame. These line junctors are used on terminating calls. It is obvious, therefore, that the same line links and the same primary switch verticals are used for both originating and terminating calls. Thus, the crossbar system line link frame corresponds to both the line finder frame and the final frame of the panel system.

Each line link frame has associated with it a "control circuit" whose function it is to recognize a calling line, chose an idle line link and assist in the selection of an idle district junctor and to operate the necessary selecting and holding magnets for connecting these paths together. On a terminating call it assists in setting up the call from the incoming trunk over a line junctor and line link to the called line.

Fig. 3 shows the arrangement of equipment on the line link frame. The secondary switches are mounted directly one above another on the left hand bay. The primary switches are mounted on the right hand bays in a similar manner, each primary bay representing 100 or 200 lines in accordance with whether 100 point or 200 point switches are employed. Fig. 4 shows several line link frames adjacent to each other in the same line.

DISTRICT FRAME GROUP

Fig. 5 shows the district frame group, which includes the subscriber sender link, district junctor, and district link frames. Each such group of three frames serves 100 district junctors.

DISTRICT LINK FRAME

The district link and district junctor frames together correspond to the district frame of the panel system.

The district link frame employs the primary-secondary arrangement of crossbar switches using ten 200 point primary switches and ten 200 point secondary switches. One hundred district junctors from line link frames are terminated on the 100 horizontal rows of contacts on the primary switches. Two hundred office junctors to the office link frames are terminated on the verticals of the secondary switches. The primary and secondary switches are interconnected by means of 200 district links appearing on the 200 vertical units of the ten primary switches and on the 100 horizontal rows of contacts of the ten secondary switches (see Fig. 6C). Each horizontal row of contacts on the secondary switches accommodates two links, the strapping for each row being divided between the tenth and eleventh verticals (split horizontals). Thus, the ten district junctors which occupy the ten horizontal rows of contacts on a primary switch have access to twenty links which are distributed over ten secondary switches so arranged that twenty groups of office junctors (ten junctors each) are made accessible to them.

DISTRICT JUNCTORS

Each district junctor includes a relay circuit which provides talking battery and supervision for the calling subscriber and controls the operation of the subscriber message register on all calls dialed directly by subscribers. These functions are similar to those performed by the district circuit of the panel system and the "A" board cord circuit in the manual system.

SUBSCRIBER SENDER LINK FRAME

Subscriber senders are selected for each call by the subscriber sender link frame, whose functions are similar to the link frame of the panel system. The subscriber sender link frame consists of primary and secondary switches whose function it is to connect an idle subscriber sender to the particular district junctor which has been selected for a given call (see Fig. 6E). Since this frame must operate before the subscriber begins to dial and before the originating marker has been connected it must be provided with a control circuit. This control circuit assists the line link control circuit in choosing the particular district junctor to be used on the call and also determines which sender is available.

The terminating sender link frame performs a similar function to the subscriber sender link frame in connecting an idle terminating sender to the particular incoming trunk on terminating calls (see Fig. 6B).

SUBSCRIBER SENDER

The subscriber senders of the crossbar system are similar to and perform much the same functions as those of the panel system except that they do not control the setting up of the paths between the calling line and the outgoing trunk. On a call to a panel office, they will control the incoming and final selectors in the distant office on a revertive pulsing basis. On a call to another crossbar office, the required number will be passed to a full selector "terminating" sender in the distant office also by means of revertive pulsing. Calls to manual offices will be handled on a call indicator basis in the same manner as for panel subscriber senders.

ORIGINATING MARKER

The originating marker of the crossbar system besides performing the functions of the panel decoder in "decoding" the office code dialed by the subscriber, also selects the combination of paths to be used between the calling line and the trunk to the particular office required. The originating marker selects an idle trunk to the office required. This determines the point on the office link frame to which the trunk to the desired office is connected. The marker also proceeds to connect this trunk to the district junctor on which the call is waiting by choosing an available combination of district link, office junctor, and office link suitable for making the connection. The marker is responsible for establishing the proper charge condition in the district junctor.

OFFICE LINK FRAME

The office link frames are arranged in a manner similar to the district link frames. Each office link frame consists of a unit of ten primary switches and ten secondary switches all of the 200 point type. Two hundred office junctors from district link frames terminate on the vertical units of the office primary switches as illustrated on Fig. 6F. Two hundred office links between the primary and secondary switches appear on the horizontal rows of terminals of the primary switches and on the 200 vertical units of the secondary switches as illustrated on Fig. 6D. The strapping on each horizontal row of terminals on the primary switch is divided between the tenth and eleventh vertical units so that each row accommodates two links. The outgoing trunks appear on horizontal rows of terminals of the secondary switches and these rows may or may not be split so that one row may serve either one or two outgoing trunks, depending upon the traffic density.

It is the practice in a crossbar office to assign the trunks to a given office to two different office frames. This insures that if a trouble condition occurs on one office frame a call to a given office will be completed over a trunk available through the second office frame.

INCOMING FRAME GROUP

The terminating sender link, incoming trunk, and incoming link frames are grouped in a manner similar to that for the district frame group. Each such group of three frames serves 100 incoming trunks.

INCOMING LINK FRAME

The incoming link and incoming trunk frames together correspond to the incoming frame of the panel system.

Incoming trunks appear on the horizontals of the primary switches on incoming link frames, (see Fig. 6C). The line junctors which are used to connect the incoming link frame to the line link frame for terminating calls appear on the verticals of the secondary switches. Between the primary switch verticals and the horizontals of the secondary switches are wired incoming links. On a terminating call it is, therefore, necessary to choose an incoming link, a line junctor, and a line link in order to complete a call between a particular incoming trunk and the desired called line.

INCOMING TRUNKS

Each incoming trunk includes a relay circuit which provides talking battery and supervision for the called subscriber where required and rings the called subscriber bell. These functions are similar to those performed by the incoming selector of the panel system and the incoming trunk of the manual system.

TERMINATING SENDER LINK FRAME

The terminating sender link frame connects an idle full selector or "B" sender to the particular incoming trunk on terminating calls (see Fig. 6B).

TERMINATING SENDERS

Terminating senders are of two kinds: Full Selector and "B" Senders.

A call from a panel or crossbar office will be registered in a full selector sender. In either case the sender registers the call by means of revertive pulses to the sender in the originating office. If the call is from a manual office the manual "A" operator will pass the number to a "B" operator in the crossbar office who will in turn transmit it by key set to a "B" sender.

TERMINATING MARKER

The function of the terminating marker is to connect the call waiting on an incoming trunk to the called line by choosing an available combination of incoming link, line junctor, and line link for making the connection. As soon as the terminating sender has registered the number, it connects itself to a terminating marker and passes the number to the marker. This information is used by the marker to determine the location of the called line. The marker also establishes the proper ringing condition in the incoming trunk.

NUMBER GROUP CONNECTOR AND BLOCK RELAY FRAMES

From the digits of the called number the marker determines the "number group" in which it is located. A number group is a group of numbers, varying in size with traffic conditions which the marker treats as a unit. Having obtained access to the number group through the number group connector frame the marker also proceeds to operate a "twenty block" relay on a block relay frame representing the block of twenty consecutive numbers containing the called line. From the block relay, the marker obtains information as to the location of the line on the line link frame.

LINE CHOICE CONNECTOR AND LINE JUNCTOR CONNECTOR

After determining the location of the called line the terminating marker obtains connection to the particular line link frame and the particular group of line junctors necessary for the call through the line choice connector and line junctor connector frames. A line choice is the association of four line link frames which are treated as a unit by the marker in setting up terminating calls.

CONNECTORS

The district and office link frames are controlled by the originating marker and hence do not require their own control circuits. They are, however, provided with "connectors" consisting of relays mounted on each district and office link frame which enable the originating marker to gain temporary access to these frames and exercise the necessary control. An incoming link frame is also provided with a connector giving access to the terminating marker.

In order to permit originating senders to obtain access to originating markers, each sender is wired to an "originating marker connector" frame through which it may be connected to an idle marker. Terminating senders obtain access to terminating markers through "terminating marker connector" frames.

Having described the functions of the various frames separately, it is now possible to take up, in the next two chapters, the interrelation of these frames in handling originating and terminating calls as illustrated schematically on Fig. 7.

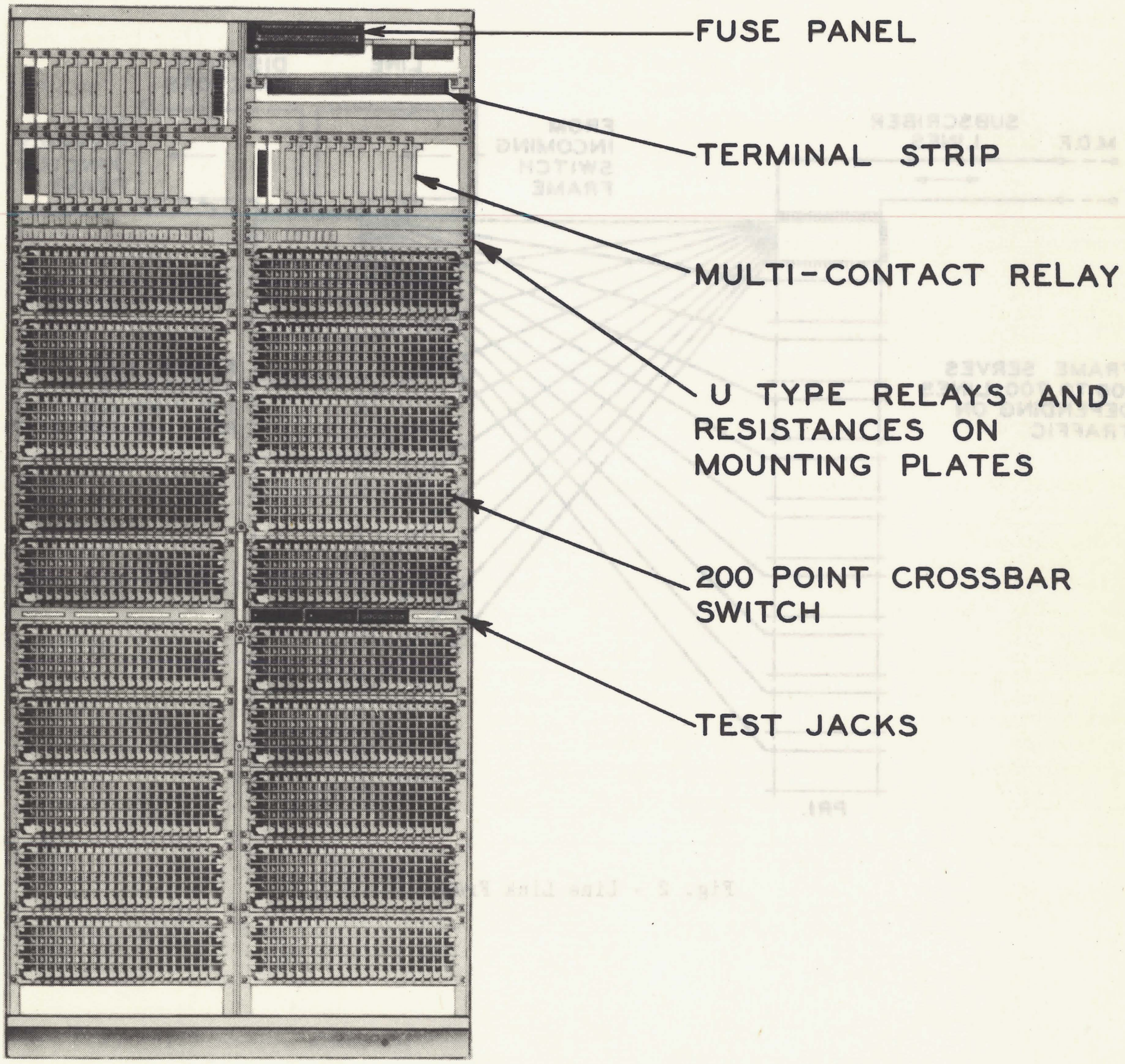

FUSE PANEL
TERMINAL STRIP
MULTI-CONTACT RELAY
U TYPE RELAYS AND RESISTANCES ON MOUNTING PLATES
200 POINT CROSSBAR SWITCH
TEST JACKS

Fig. 1 - Typical Crossbar Switch Frame

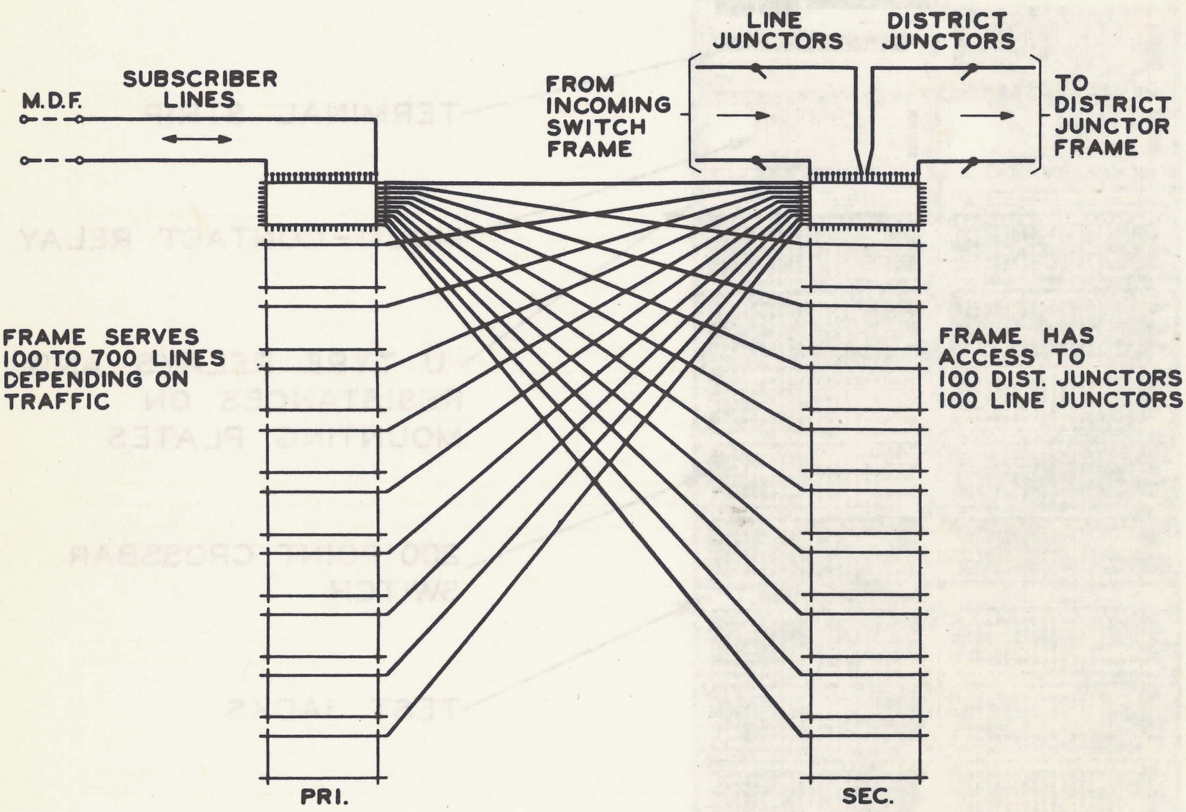

LINE JUNCTORS
DISTRICT JUNCTORS
SUBSCRIBER LINES
M.D.F.
FROM INCOMING SWITCH FRAME
TO DISTRICT JUNCTOR FRAME
FRAME SERVES 100 TO 700 LINES DEPENDING ON TRAFFIC
FRAME HAS ACCESS TO 100 DIST. JUNCTORS 100 LINE JUNCTORS
PRI.
SEC.

Fig. 2 - Line Link Frame

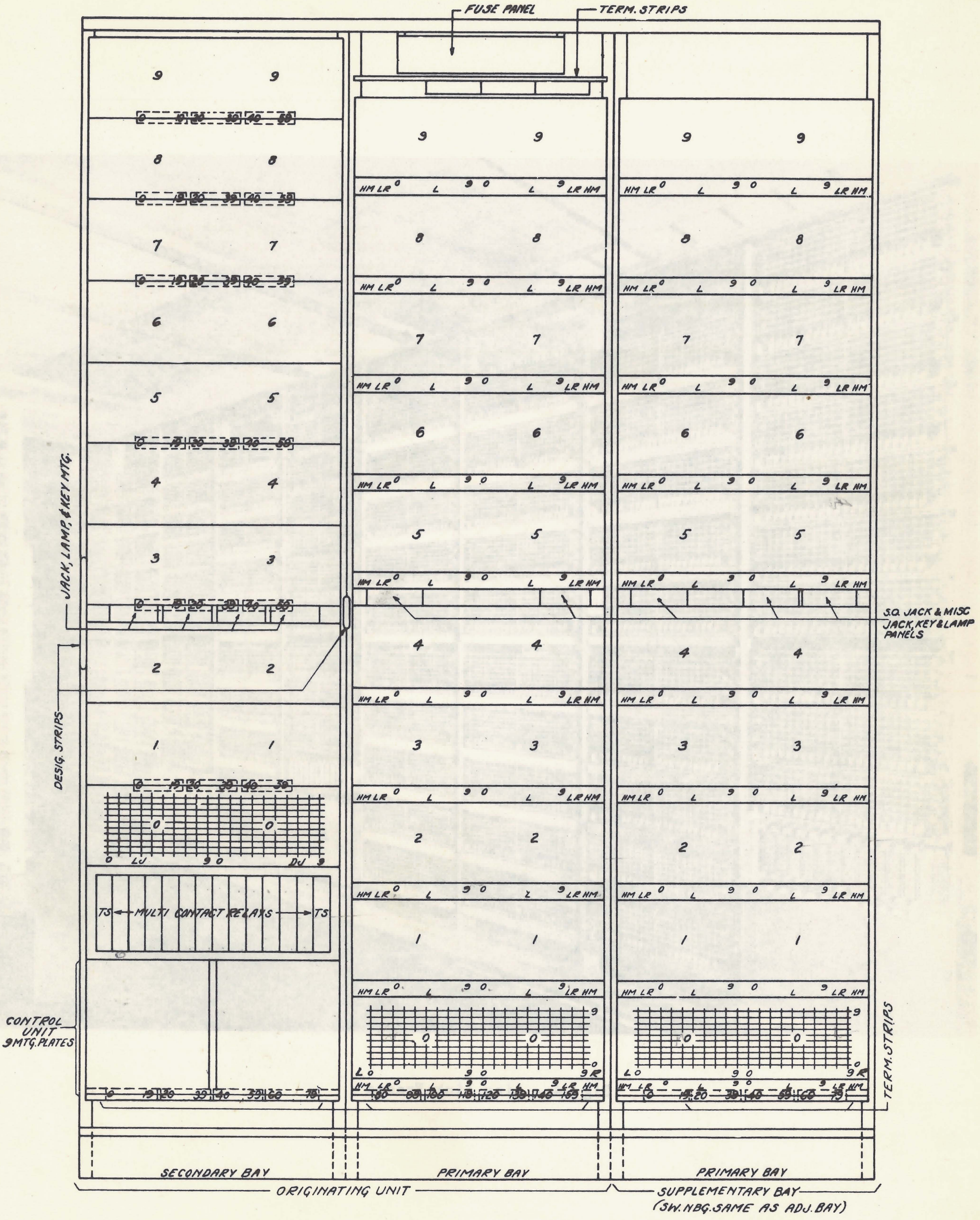


Fig. 3 - General Appearance of Line Link Frame

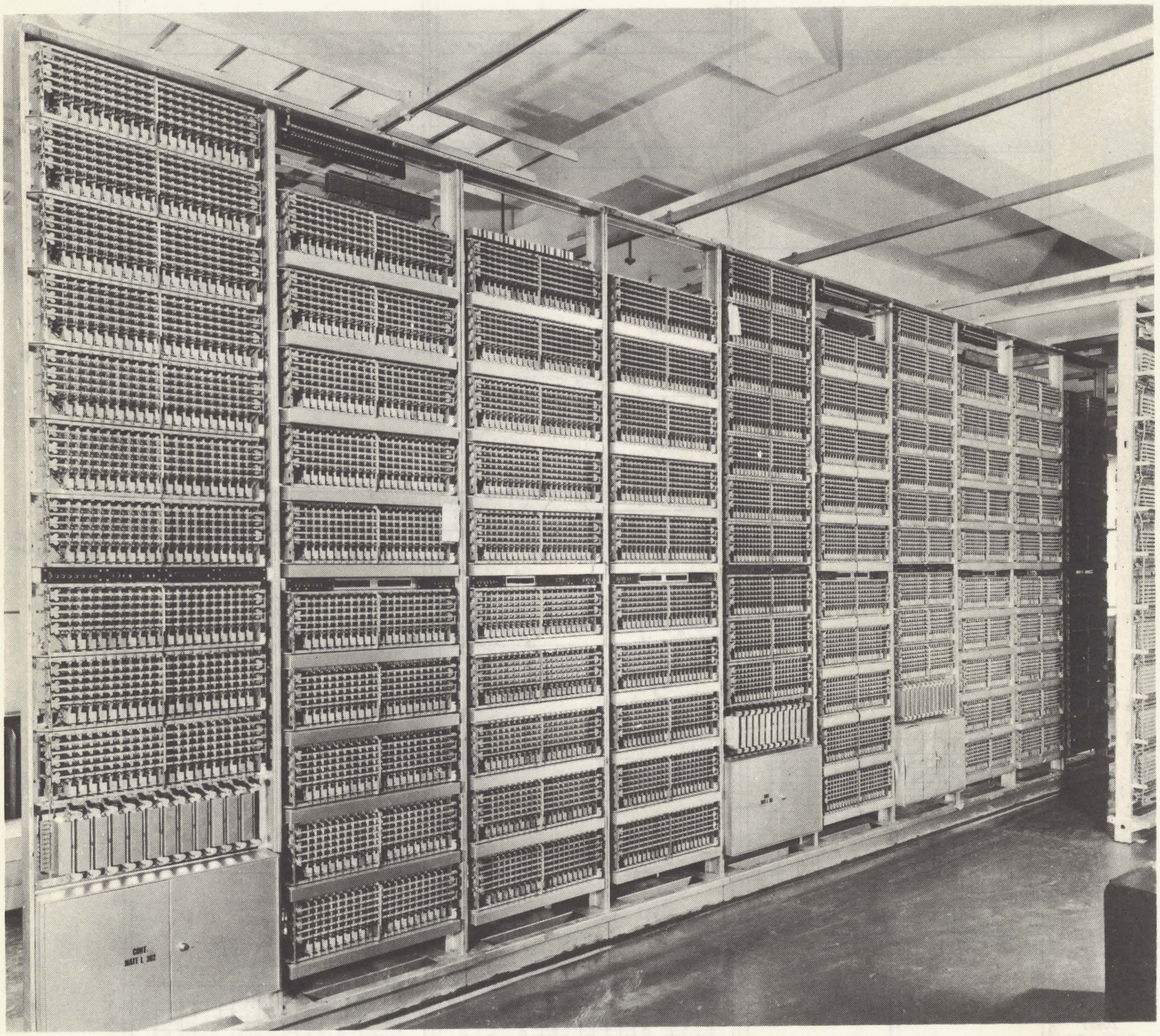


Fig. 4 - Line Link Frames

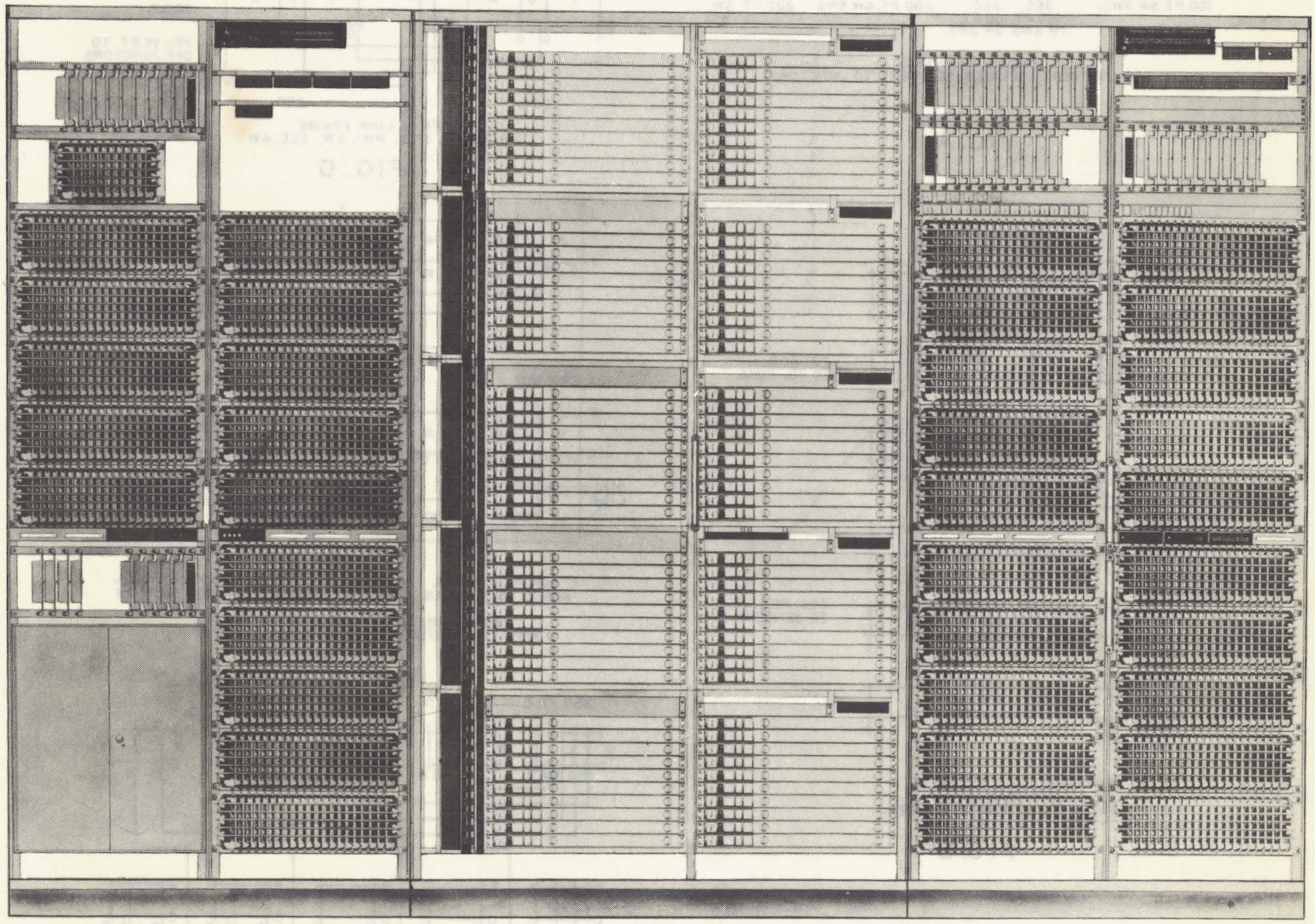
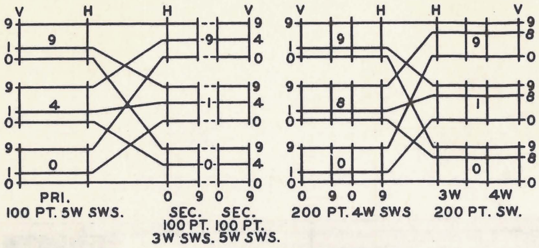
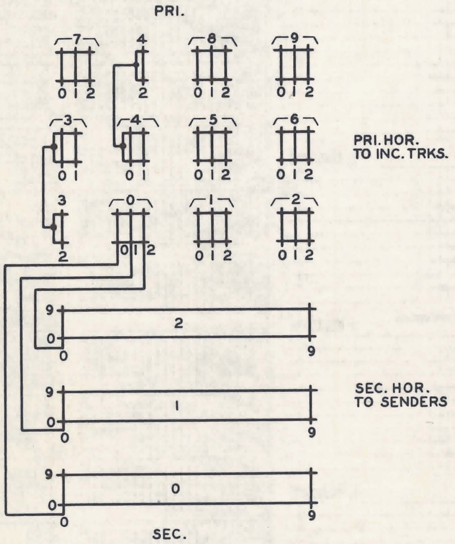


Fig. 5 - District Frame Group



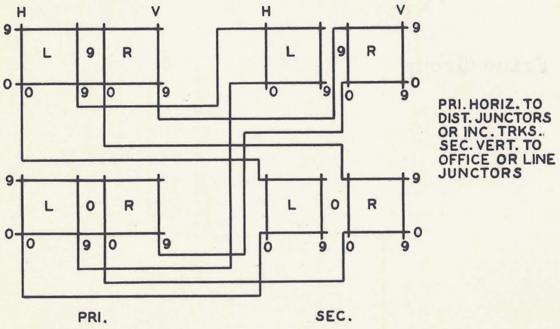
LINE LINK FRAME
PRI. VERT. TO LINES, SEC. VERT. TO JUNCTORS

FIG. A



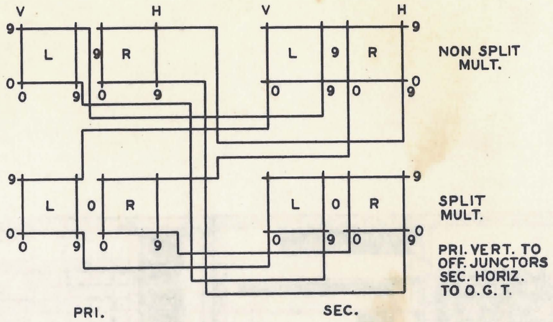
TERMINATING & "B" SENDER
LINK FRAMES
3 PRI. & 3 SEC. 100 PT. 6W SWS.

FIG. B



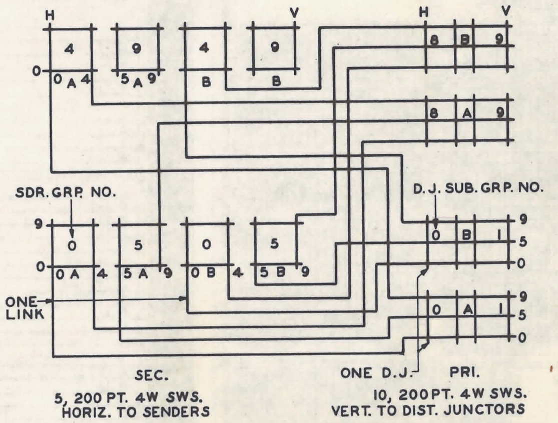
DISTRICT LINK & INCOMING LINK FRAMES
20, 200 PT. 3W SWS.

FIG. C



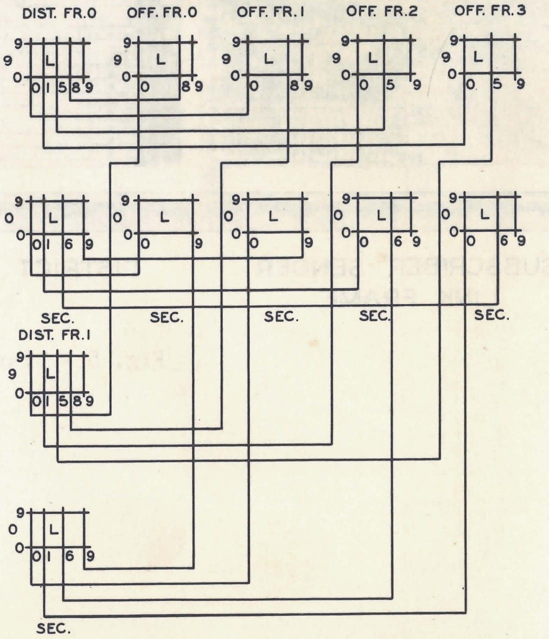
OFFICE LINK FRAME
20, 200 PT. SWS. PRI. 3W, SEC. 4W

FIG. D



SUBSCRIBERS SENDER LINK FRAME
8 WIRE LINK CKTS. WITH 2 VERT. UNITS PER LINK

FIG. E



TRUNKING BETWEEN DIST. & OFF. LK. FRS.
CONNECTIONS FOR 4 DIST.—4 OFFICE FRS.

FIG. F

Fig. 6 - Frame Trunking Plans

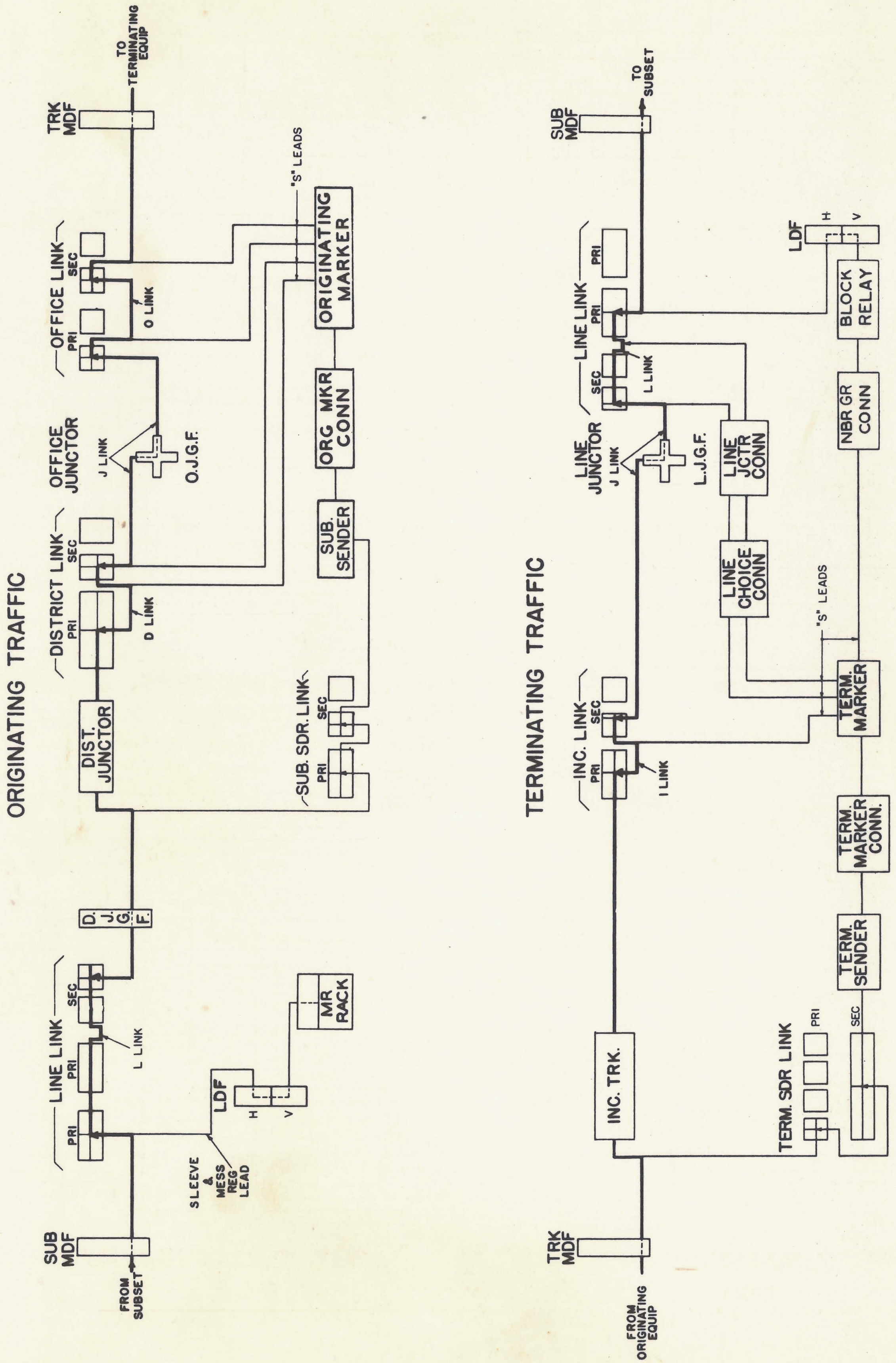


Fig. 7 - Crossbar System Traffic Schematic

CHAPTER 3 - CROSSBAR SYSTEM - ORIGINATING CALLS

With the exception of the line link frame, the crossbar equipment for originating calls is entirely separate from that used for terminating calls. This chapter will deal only with the originating equipment and will show how a calling subscriber line is found and connected to an idle outgoing trunk to the required office. The general procedure for this part of the call is the same regardless of whether the distant office is crossbar, panel, or manual.

CROSSBAR - A MARKER SYSTEM

The panel and step-by-step systems set up a call on a "hunting" basis. As soon as an idle path, going in the proper direction, is found, the path is seized and immediately used to progress to the next diverging point, where this operation is repeated.

The crossbar system sets up its calls on a "marker" basis. The establishment of a call is broken up into four general steps (two in the originating and two in the terminating equipment) and the termination of each step is "marked" before any of the intervening paths are actually seized. In the first step in the originating equipment, the subscriber sender to be used on a particular call is chosen before the line link, district junctor, and sender link are connected to the subscriber line. In the second step, the outgoing trunk is chosen before the district link, office junctor, and office link are tested. The third and fourth steps, in the terminating equipment, are connecting an idle terminating sender to the incoming trunk and connecting the called subscriber to the incoming trunk.

FINDING THE CALLING LINE

Each subscriber line terminates on a vertical unit of a line link primary switch and the line relay associated with each line is located immediately beneath the corresponding switch. When the calling subscriber receiver is removed from the switchhook, the line relay is operated as in other systems.

Before the subscriber can proceed to dial the required number, however, he must be connected to a sender and must receive dial tone. The line link frame and the subscriber sender link frame are responsible for setting up this connection, that is, for connecting the calling line to an idle district junctor and also for connecting the district junctor to an idle subscriber sender.

As previously stated, there is associated with each line link frame a control circuit. This circuit is caused to function by the operation of any line relay on the frame. Each line has access to only ten line links so that the control circuit must recognize which line is calling and then connect that line to an idle line link by operating the proper primary switch selecting magnet and holding magnet.

The line link control circuit identifies the horizontal group (the primary switches having access to the same ten line links) in which the calling line appears and then the vertical group (the 100 lines represented by ten primary switches mounted directly one above the other). These two identifications show in which ten lines on the line link frame the calling line appears, as may be seen from Fig. 1. The control circuit tests this group of ten lines for the operated line relay and thus determines which primary holding magnet is to be operated.

The control circuit also tests the ten line links of the horizontal group in which the calling line appears and chooses one which is idle. This choice is made in conjunction with the sender link control circuit. Since each line link horizontal group has only one line link to each group of ten district junctors, which of the idle line links is to be used will depend upon which group of ten district junctors is to be used for the call. By operating the various primary selecting magnets associated with the line link followed by the operation of the line holding magnet, the calling line may be connected to an idle line link, as shown schematically on Fig. 2.

It will also be necessary to connect the line link to an idle district junctor. As stated above, a particular line link has access through the secondary switch on which it appears to ten district junctors. The line link control circuit chooses one of these ten district junctors which is idle. The line link may be connected to the district junctor by the operation of the secondary selecting magnet associated with the line link followed by the operation of the holding magnet associated with the district junctor. By means of Fig. 2, the calling line may now be traced through a line link to a district junctor. This is comparable with the panel condition where the line finder has found the calling line and extended it to a district selector.

SEIZURE OF SUBSCRIBER SENDER

Before the process of choosing an idle district junctor, the subscriber sender link frame associated with the district frame on which the chosen district junctor appears has selected an idle subscriber sender.

The control circuit on the subscriber sender link frame assisted the line link control circuit in choosing an idle district junctor.

This district junctor appears on the vertical of the primary switch on the subscriber sender link frame as well as on the secondary switch of the line link frame. The subscriber senders are wired to the horizontals of the secondary switches. The control circuit must choose an idle sender and operate the secondary selecting magnet associated with the horizontal terminals on which this sender appears and the primary selecting magnet associated with the horizontal terminals on which the sender link appears. The operation of the primary holding magnet associated with the district junctor and the secondary holding magnet associated with the sender link will connect the district junctor to the idle sender.

As soon as the line link, district junctor, and subscriber sender to be used on the call have been determined, the necessary magnets required to connect the calling line to the sender are operated. The calling subscriber will now receive dial tone over the path provided by the line link, the district junctor, the subscriber sender link and the sender (see Fig. 2).

ACTION OF SENDER

As soon as the subscriber has received dial tone he will proceed to dial the number required. This, as in the panel system, is recorded in the sender. As soon as the sender has recorded the complete office code it proceeds to connect itself to an idle originating marker. This is done by means of an originating marker connector (see Fig. 4), which is similar in principle to the decoder connector of the panel system. As soon as the sender is connected to the marker it transmits the office code dialed by the subscriber (together with the district frame and class of service indications) to the marker.

The originating marker in turn gives the sender information which it will need for controlling the path of the call in the terminating office. This includes information as to whether the terminating office is panel, manual, or crossbar but does not include information concerning the routing of the call to an outgoing trunk since this part of the call is handled by the originating marker itself and not by the sender.

SELECTION OF IDLE OUTGOING TRUNK

The next task of the originating marker is to locate an idle trunk to the office indicated by the office code. In order to accomplish this it connects itself to the pair of office frames on which the required outgoing trunks appear. This it does by means of an "office connector" located on the office frame (see Fig. 4). The office connector consists of a group of relays which permits the marker to connect itself momentarily to the test leads of any trunk group. The marker then proceeds to test the trunks on both office frames testing one on one frame and then one on the mate office frame until an idle trunk is found. The next problem is to connect this idle trunk to the district junctor on which the call is waiting.

CHANNEL TESTING

In order to connect the district junctor, on which the call is waiting, to the idle outgoing trunk, which has just been chosen ("marked") by the marker, three paths must be connected in series between the two points. First, there must be an office junctor between the district and office frames. Second, the district junctor must be connected to an office junctor by means of a district link. Third, the office junctor must be connected to the outgoing trunk by means of an office link (see Fig. 4). Since there are a number of each of these paths which can be used on a given call it is the duty of the marker to determine which set of three paths shall be used.

The decoder marker connects itself to the test leads of outgoing trunks (as previously stated) and also to those of office links through the office connector. It obtains access to the test leads of district links and office junctors through the "district connector" located on the district frame on which the calling district appears (see Fig. 4). The proper district link frame is seized by the marker under control of the district frame indication received from the sender. The district and office connectors also provide the marker with access to the leads for operating the necessary magnets.

In the originating marker there are two "channel test" relays for each combination of three paths (district link, office junctor, and office link). If either relay is operated, the particular combination of three cannot be used. In order to notify the marker if any one of the three paths is busy the test lead for each path is connected to a different winding on the channel test relays. By means of these windings any path can indicate to the decoder immediately whether it is busy or not and if one of the three is busy the marker can proceed to find the set of three idle paths which can be used for the call.

CONNECTING TO OUTGOING TRUNK

As soon as the marker has satisfied itself that a particular set, including a district link, office junctor, and office link is available to connect the calling district to an outgoing trunk, it proceeds to operate first the district and office selecting magnets and then the necessary holding magnets to connect the subscriber line to the outgoing trunk over the combination of paths selected. As soon as this has been done the marker is disconnected from the call and is made available for another. The steps taken by the marker are summarized on Fig. 3.

The subscriber sender, however, remains on the call long enough to direct its handling through the terminating office. The set-up in the originating office is now as shown on Fig. 5. The holding magnets shown (except those of the sender link) remain operated until the conclusion of the conversation.

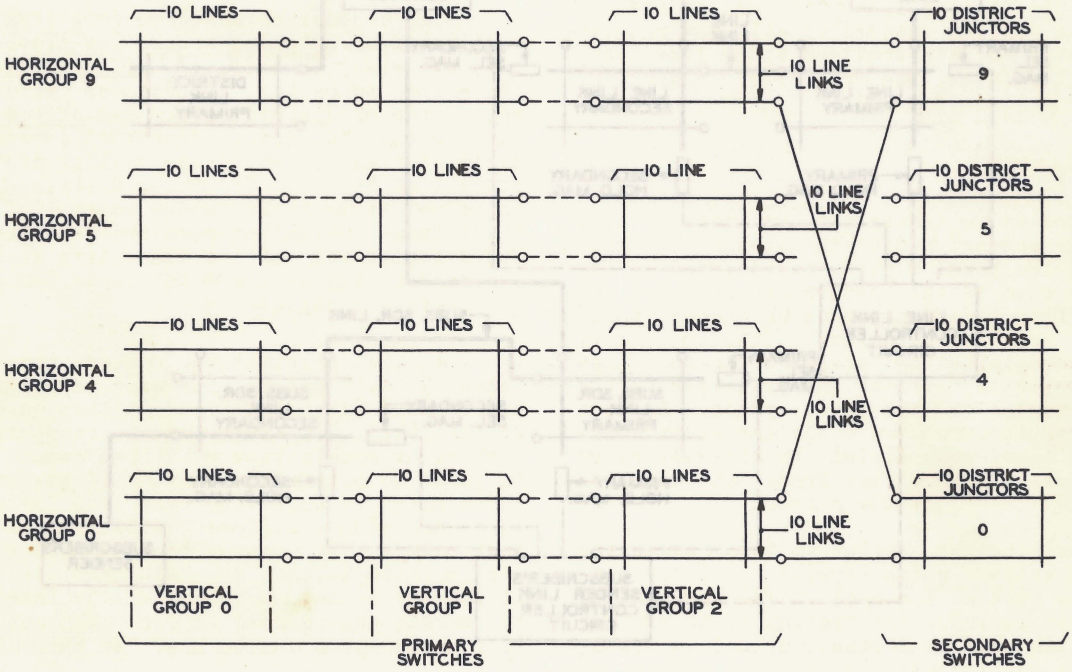


Fig. 1 - Line Link Frame Schematic

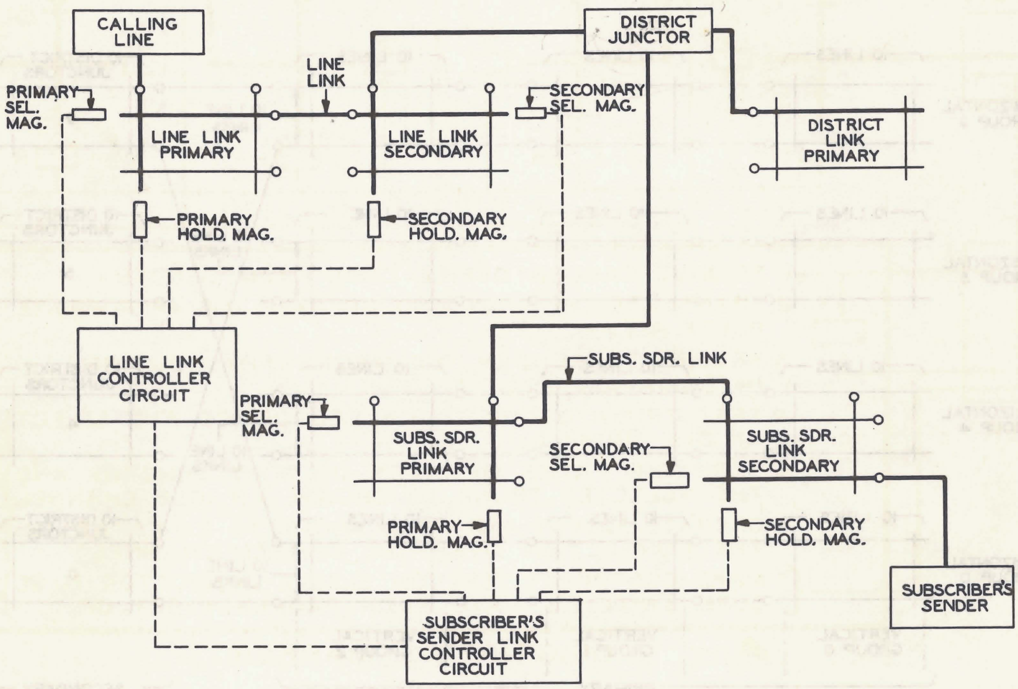
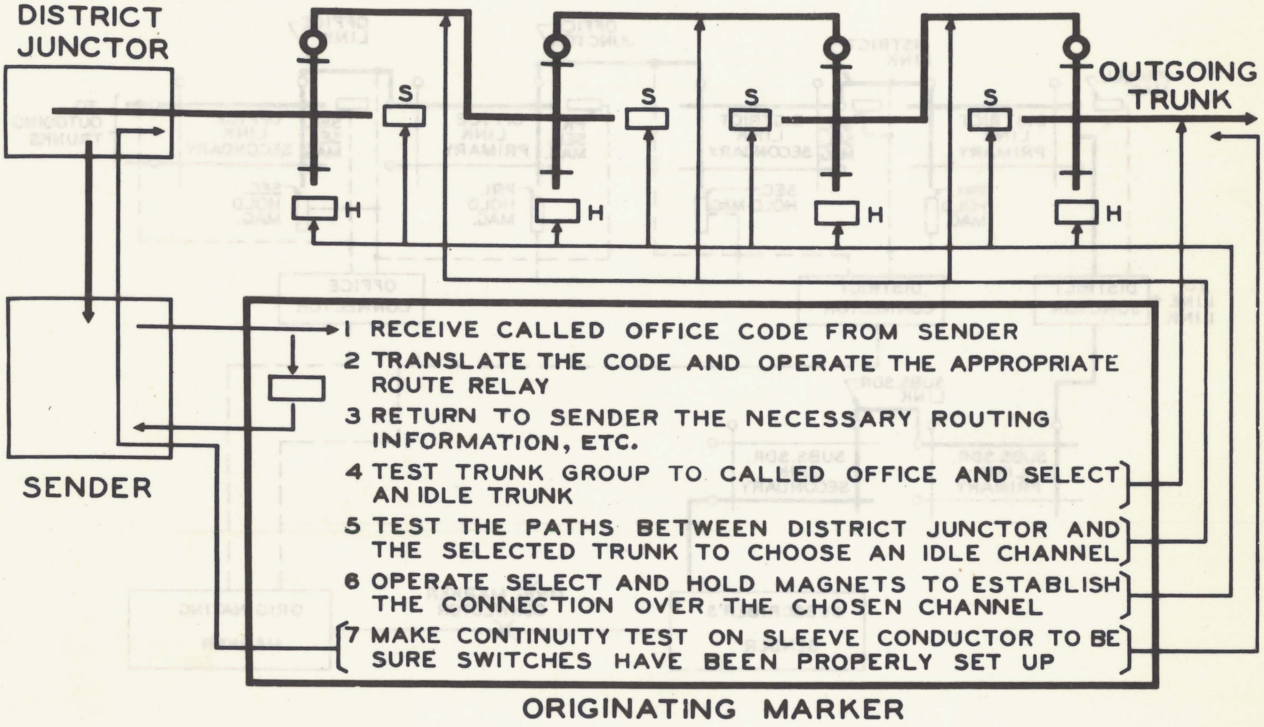


Fig. 2 - Calling Line Connected to Subscriber Sender



1 RECEIVE CALLED OFFICE CODE FROM SENDER
2 TRANSLATE THE CODE AND OPERATE THE APPROPRIATE ROUTE RELAY
3 RETURN TO SENDER THE NECESSARY ROUTING INFORMATION, ETC.
4 TEST TRUNK GROUP TO CALLED OFFICE AND SELECT AN IDLE TRUNK
5 TEST THE PATHS BETWEEN DISTRICT JUNCTOR AND THE SELECTED TRUNK TO CHOOSE AN IDLE CHANNEL
6 OPERATE SELECT AND HOLD MAGNETS TO ESTABLISH THE CONNECTION OVER THE CHOSEN CHANNEL
7 MAKE CONTINUITY TEST ON SLEEVE CONDUCTOR TO BE SURE SWITCHES HAVE BEEN PROPERLY SET UP

Fig. 3 - Operation of Originating Marker

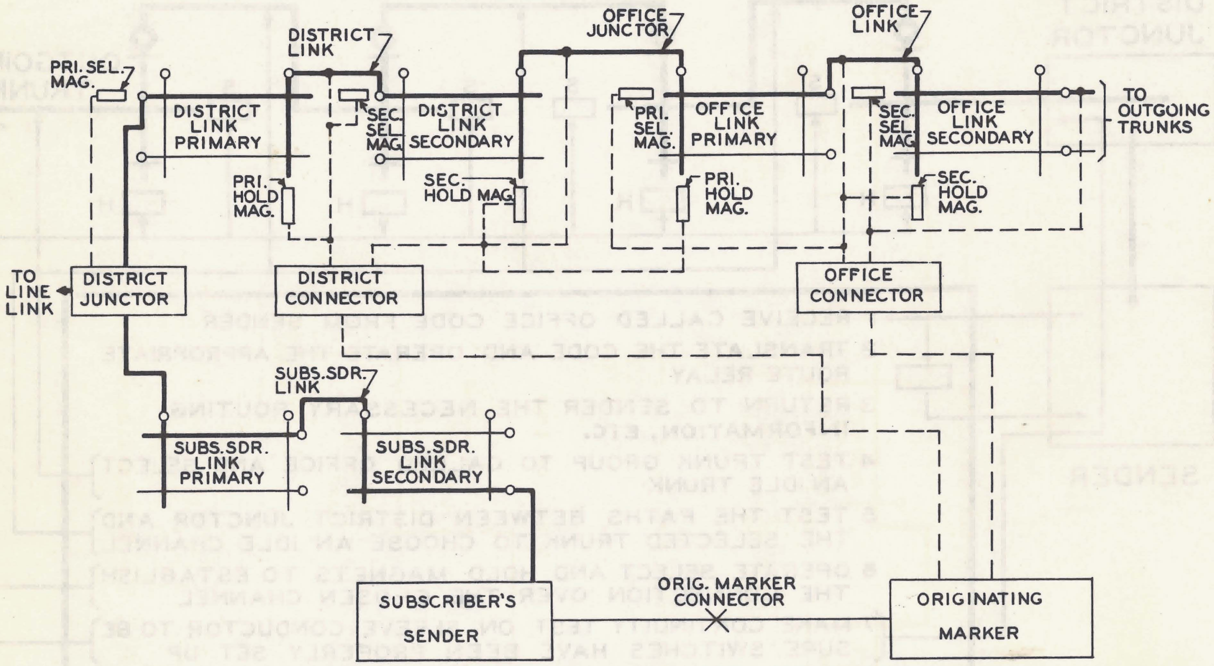


Fig. 4 - Connection of District Junctor to Ougoing Trunk

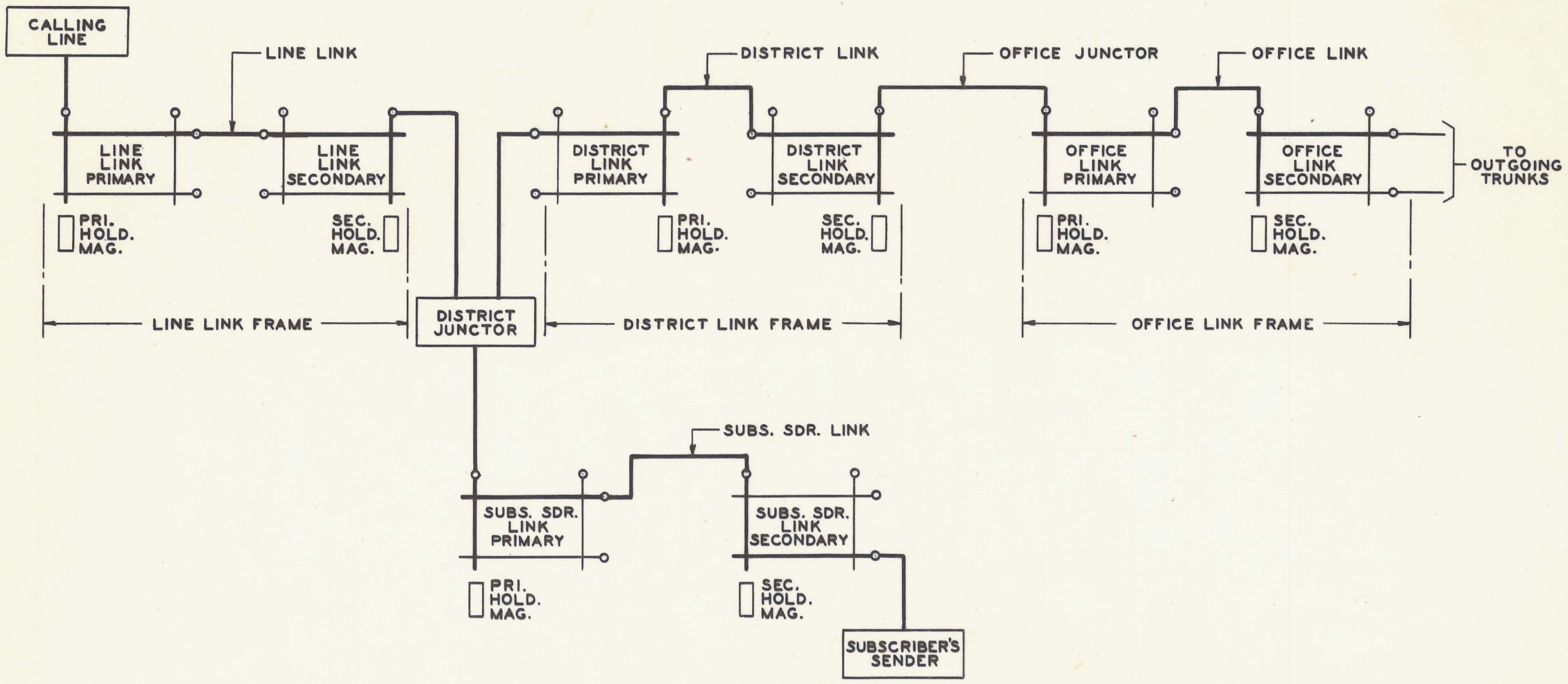


Fig. 5 - Originating Call

CHAPTER 4 - CROSSBAR SYSTEM - TERMINATING CALLS

The previous chapter discussed the originating of calls in a crossbar office, the method of routing the call to an outgoing trunk being the same whether the call is to be completed in a crossbar, panel, or manual office. The present chapter discusses the handling of the call in the terminating crossbar office, the method of operation being, in general, the same whether the call originates in a panel or a crossbar office. The handling of a call originating in a manual office differs somewhat, however, so that the completion of this type of call will also be discussed.

CROSSBAR TO CROSSBAR CALL

As discussed in the previous chapter, the calling line in the originating crossbar office is connected to an outgoing interoffice trunk to the terminating crossbar office. The subscriber sender remains on the call long enough to register the called number in the terminating sender in the terminating office.

CROSSBAR SYSTEM - INTEROFFICE TRUNKS

The interoffice trunks are outgoing from the horizontal terminals of the secondary switches on the office link frame in the originating office. In the terminating crossbar office they appear on the horizontal terminals of primary switches on an incoming link frame.

These trunks correspond to the incoming trunks of the panel system which are terminated as selectors on an incoming frame. Each trunk includes relay equipment which provides talking battery, ringing, and supervision for the called subscriber, as in the panel system. They also provide overflow (all paths busy) and busy signals for the calling subscriber, the latter feature being provided by the final selector in the panel system.

TERMINATING SENDER - FULL SELECTOR AND "B" OPERATOR

Terminating senders are of two kinds: Full Selector and "B" Senders.

Full selector senders are employed in crossbar offices on terminating calls which originate in panel or crossbar offices. The sender handles calls from either type of office in the same manner. It does this by means of revertive pulsing, the effect on the originating sender (whether crossbar or panel) being the same as if the revertive pulses were coming from the commutators of panel incoming or final selectors. The action of the sender in sending the required pulses back to the subscriber sender leaves the called number registered in the sender. The subscriber sender in the originating office is then no longer required and is dismissed from the call.

ATTACHING A TERMINATING SENDER TO AN INCOMING TRUNK

The action involved in attaching a terminating sender of either kind to an incoming trunk for the handling of an incoming call is similar to that which takes place in attaching a subscriber sender to a calling line in the originating crossbar office. A "terminating sender link frame" is provided for this purpose (see Fig. 1). The incoming trunks appear on the horizontals of primary switches on this frame and the terminating senders on the horizontal terminals of the secondary switches. The connections between primary and secondary switches are referred to as "terminating sender links" and the choice of an idle sender and the operation of the necessary magnets to connect it to a particular trunk by means of a link is performed by the terminating sender link control circuit (see Fig. 1). Incoming trunks requiring access to full selector senders and those requiring "B" senders may be associated with the same terminating sender link frame, the trunk indicating to the link frame which type of sender is required.

CONNECTION TO TERMINATING MARKER

The number registered in the terminating sender is transferred to a "terminating marker" which controls the setting up of the call between the incoming trunk and the called line. The sender and terminating marker are connected together by a marker connector similar to the originating marker connector in the originating crossbar office. The terminating marker now proceeds to locate the particular called number in order to determine what combination of paths will be required in setting up the call.

ACTION OF TERMINATING MARKER

The terminating marker is similar to the originating marker in that it contains no switches but consists entirely of relays, terminal strips, etc. From the digits of the number registered in the terminating marker, the marker determines in which "number group" the called number is located. A number group is a group of numbers which the marker treats as a circuit unit and into which only one marker may work at a time. The terminating marker obtains access to the particular number group through a "number group connector" frame and operates a "twenty block relay" serving the twenty lines in which the called line appears. Through this relay the marker obtains access to the sleeve of the required line and also obtains information as to the line choice in which the required line is located.

All the lines in the office are divided into "choices", each choice consisting of those lines served by four line link frames. The actual number of lines in a choice varies depending upon the number of lines served by each line link frame. The "line choice connector" gives the marker momentary control over the line link frame on which the called line is located as shown on Fig. 1. Associated with the line choice connector is the "line junctor connector" which gives the marker access to the test leads of line junctors and permits it to operate the required selecting and holding magnets to complete the call.

CONNECTING TO CALLED LINE

The number group connector tests the called line for busy and if it is found idle when the busy test is made, the terminating marker proceeds to set up a connection to it. In order to accomplish this it requires the assistance of the line link control circuit as well as the other frames described above. If the control circuit happens to be busy on an originating call, the marker waits for its release after which it takes momentary possession of the line link frame to the exclusion of originating calls. In case of simultaneous attempts by several terminating and originating calls for the use of the same line link frame, terminating and originating calls will alternate until all have been served.

In order to connect the incoming trunk to the called line, a combination of three paths is required. First, there must be a line junctor to connect the incoming frame to the line link frame (incoming link secondary switch to line link secondary switch); second, there must be an incoming link to connect the incoming trunk to the line junctor (incoming link primary to incoming link secondary switch); third, there must be a line link to connect the line junctor to the called line (line link secondary to line link primary). The terminating marker obtains control over the test leads of the available incoming links through an "incoming connector" and over those of the line junctors and line links through the line junctor connector. Since there are a number of each of these paths which may be available for a particular call, the terminating marker determines which particular combination of three shall be used by a channel testing process similar to that described previously for the originating marker in the originating office.

As soon as an idle combination has been found, the terminating marker in conjunction with the line link control circuit, line choice connector, and line junctor connector operates the necessary selecting and holding magnets to connect the incoming trunk to the called line over the combination of paths chosen and then disconnects itself. The steps taken by the marker are summarized on Fig. 2.

The incoming trunk circuit rings the called subscriber bell and supplies him with talking battery. The call in the terminating office is now complete from the incoming trunk through the incoming link and line link frames to the called line.

MANUAL TO CROSSBAR CALL

Calls originating in manual offices for completion in crossbar offices are handled by means of a call distributing "B" switchboard. This process is illustrated on Fig. 4. "B" senders are provided in which the number written up on the "B" operator's keys is recorded. These "B" senders have access to terminating markers and the call is completed by the terminating marker in a manner similar to that described for calls originating in crossbar or panel offices.

COMPLETION OF CROSSBAR CALLS IN PANEL AND MANUAL OFFICES

As previously stated, the routing of an originating crossbar call to an outgoing trunk is, in general, the same whether the call is to be completed in a crossbar, panel, or manual office. After the selection of the interoffice trunk, however, the call is handled in accordance with the type of terminating office. Where the crossbar call is to be completed in a panel office, the trunks terminate as incoming selectors on a panel incoming frame, as illustrated on Fig. 3. The subscriber sender in the originating crossbar office directs the incoming and final selectors on a revertive pulsing basis to select the called number. The procedure in the terminating panel office is the same, therefore, as though the call had originated in another panel office.

A call originating in a crossbar office to be completed in a manual office is handled on a call indicator basis. The crossbar subscriber sender in this case transmits call indicator pulses to the "B" position in the manual office for the purpose of causing a display on the "B" operator's indicator.

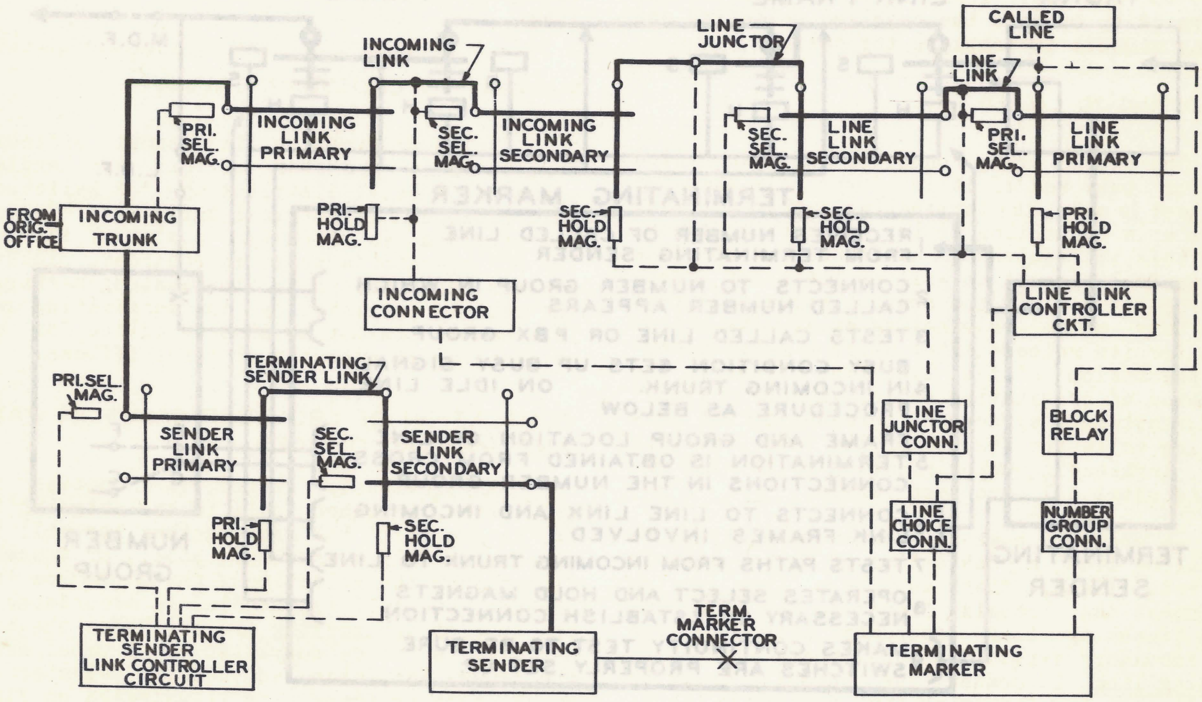
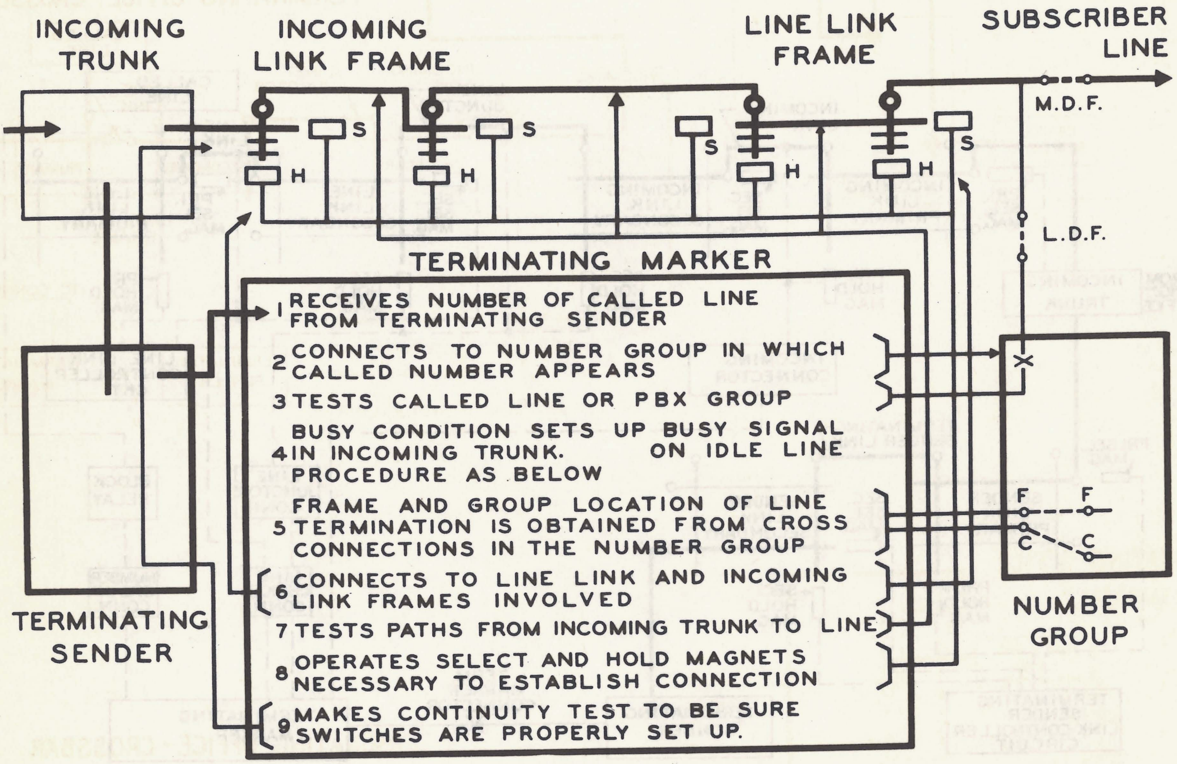


Fig. 1 - Terminating Office Connection of Incoming Trunk to Called Line



1 RECEIVES NUMBER OF CALLED LINE FROM TERMINATING SENDER
2 CONNECTS TO NUMBER GROUP IN WHICH CALLED NUMBER APPEARS
3 TESTS CALLED LINE OR PBX GROUP
4 BUSY CONDITION SETS UP BUSY SIGNAL IN INCOMING TRUNK. ON IDLE LINE PROCEDURE AS BELOW
5 FRAME AND GROUP LOCATION OF LINE TERMINATION IS OBTAINED FROM CROSS CONNECTIONS IN THE NUMBER GROUP
6 CONNECTS TO LINE LINK AND INCOMING LINK FRAMES INVOLVED
7 TESTS PATHS FROM INCOMING TRUNK TO LINE
8 OPERATES SELECT AND HOLD MAGNETS NECESSARY TO ESTABLISH CONNECTION
9 MAKES CONTINUITY TEST TO BE SURE SWITCHES ARE PROPERLY SET UP.

Fig. 2 - Operation of Terminating Marker

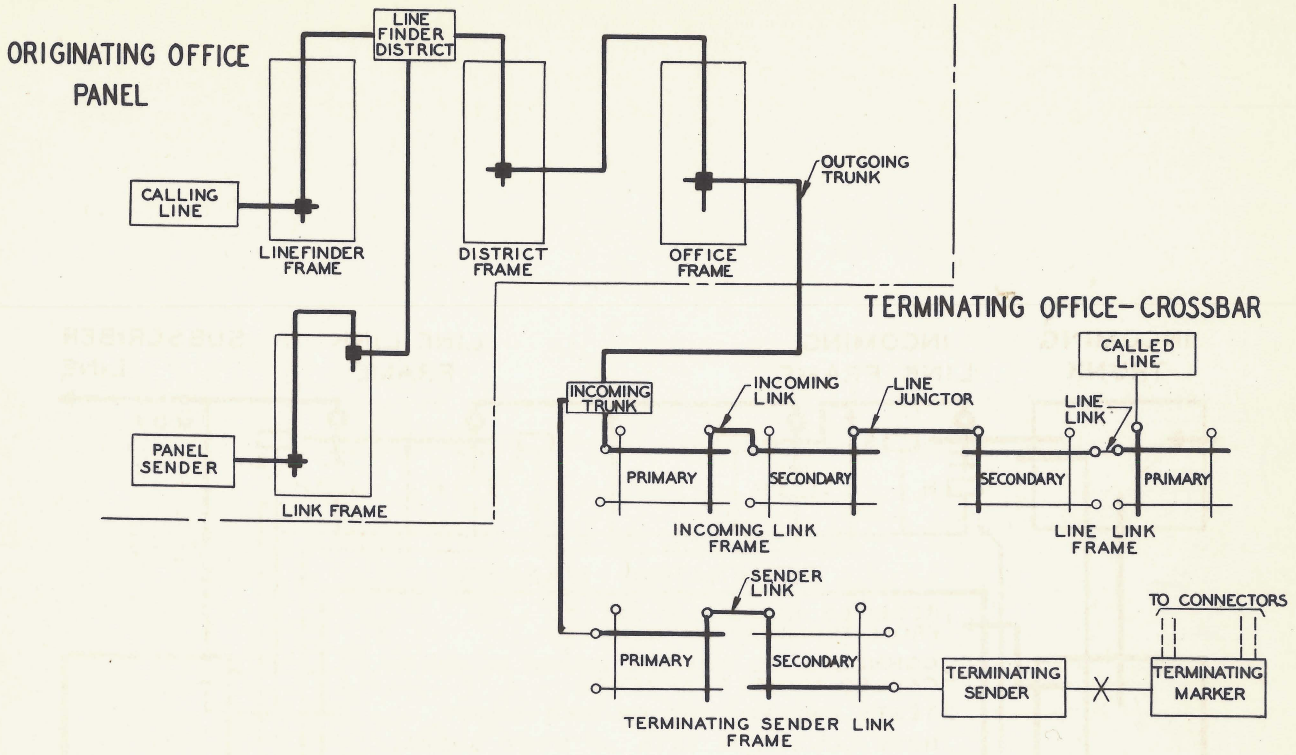


Fig. 3 - Panel to Crossbar

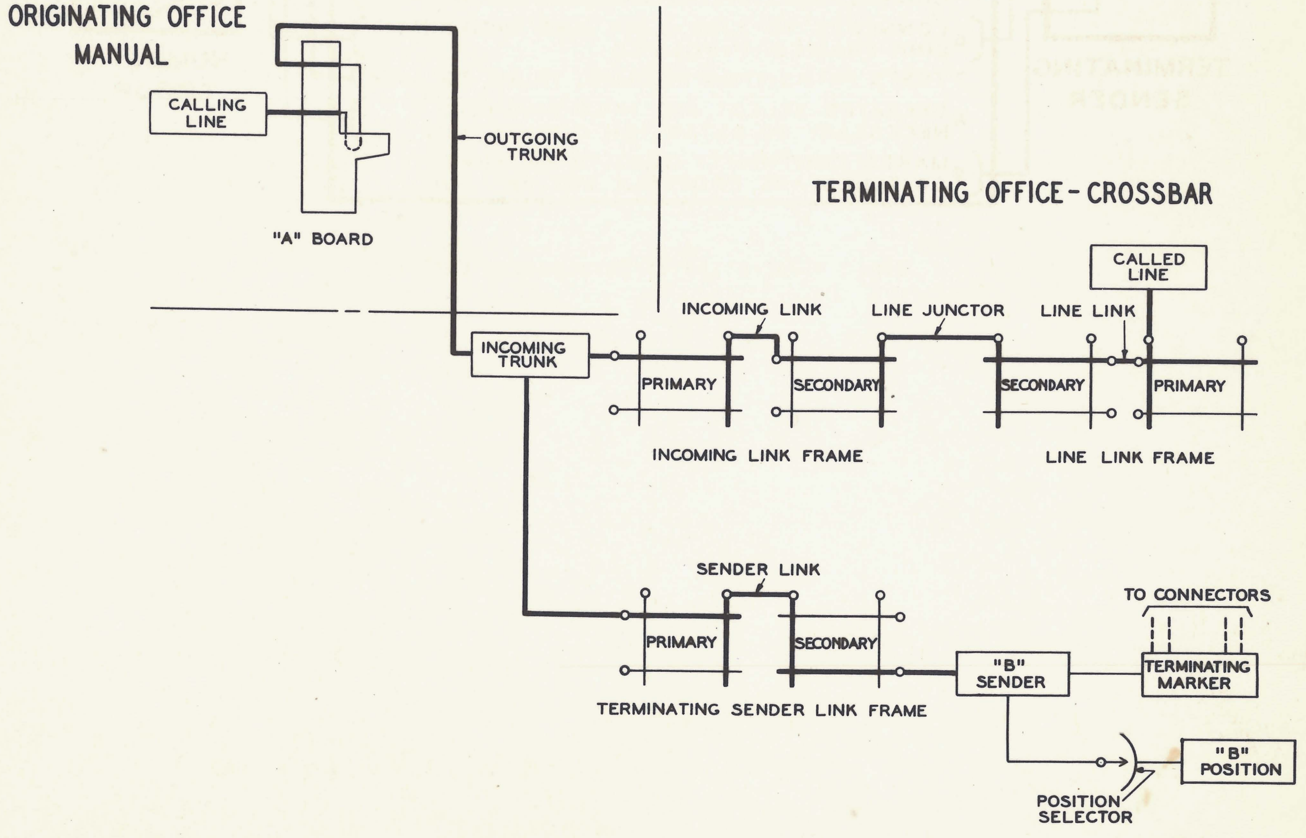


Fig. 4 - Manual to Crossbar